PUBLIC WORKS

City, County and State

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JUNE, 1936

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●

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Leaning Wheel Graders
Straight Wheel Graders
Motor Patrol Graders

Drags
Rooters
Scrapers
Spreaders

PUBLIC WORKS

City, County and State Engineering and Construction

JUNE, 1936

VOL. 67, NO. 6

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TIMEWASTERS

An All-Number Problem

There are four combinations of numbers, which when multiplied by "3" give in the multiplier, the multiplicand and the product all of the 10 digits. Who will volunteer to tell us what these four numbers are?

Bullseye?

The little target shown herewith has a peculiar system of numbering, to say the least. At any rate, our first-class rifle and pistol shots will aver that it looks a trifle strange. However that may be, get down your trusty fowling piece and see how few shots you can fire, and what scores you must make on each of the shots in order to come out with an even 100.—*From Link-Belt News.*

Kerplunk!

One of our sharks from out Indiana way contributes a simple problem, as follows: A boy standing on a high bridge over a mountain stream drops a stone into the water beneath. He hears the sound of the stone striking the water in exactly 6 seconds. How high is the bridge over the water? By *H. A. Blunk.* (Note by The Editor: We don't think it makes any difference whether it is a mountain stream or the Chicago Drainage Canal, but that's the way Mr. Blunk sent it to us.)

The Road Money:

Engineers do not seem to be financially minded, or maybe they don't care to count pennies. No one wrote in to tell us how many miles of road those pennies would surface, but we have it on the authority of the American Petroleum Institute that the money mentioned in our May issue, as having been collected in gasoline taxes, if changed into pennies would surface a road 20 feet wide and almost 20,000 miles long. Some road! They also add the valuable information that it would take a man from now till 12056 A.D. to count these pennies; moreover, that if laid end to end, they would reach for more than 6 million miles.

Well, so far as we are concerned, we can count all of our money long before 12056, and then some. And in the meantime, contributions are again respectfully—yea, earnestly—solicited. W. A. H.

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A. PRESCOTT FOLWELL, Editor — **W. A. HARDENBERGH,** Asso. Editor

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Technical specifications for materials and their application have been carefully prepared and will be furnished on request.

THE BARRETT COMPANY

40 Rector Street **New York, N. Y.**

The above illustrates the exceedingly smooth, glossy surf of Barrett Water Works Enamel applied to the interior o 60″-diameter steel water pipe.

PUBLIC WORKS

City, County and State Engineering and Construction

Vol. 67 — *June, 1936* — No. 6

Centrifugal Pumps for Water Works

Suggestions for selecting type of pump and designing plant

LOSSES of energy in a centrifugal pump are due to friction in the bearings of the impeller shaft, of water against casing and impeller, and internal friction of the water as it changes shape and velocity in passing through the pump. The first is a mechanical problem which is met by the usual methods of construction and lubrication of bearings. The bearings are preferably placed outside the casing to insure that water will not reach them. The shaft enters the casing through a stuffing box, the main purpose of which is to prevent air being sucked into the casing where it is under negative pressure; this being insured in most pumps by forcing water into a water seal ring in the middle of the stuffing box.

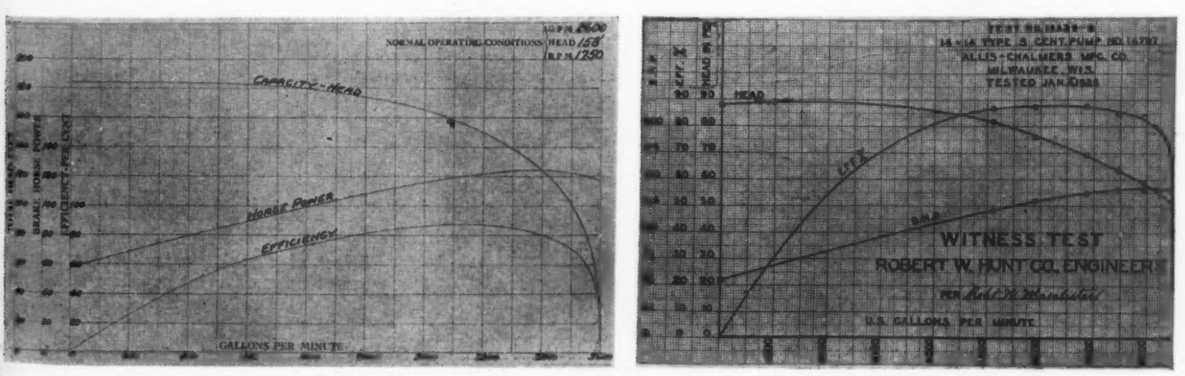
Thrust Control

In addition to the shaft bearings, there is thrust on the shaft to be balanced. In a one-stage single-suction pump, the water is sucked in from one side and the impeller is thus drawn toward that side. In a double-suction, the water is drawn in from both sides and the suction thrusts therefore balance each other theoretically, although they may vary slightly. In some multi-stage pumps, each impeller or stage is double-suction (Allis-Chalmers Type M, used for heads up to 4,000 ft.), but in most cases they are single-suction, the discharge at the circumference of one stage passing to the center of the next stage on one side only. The simplest construction conducts the water to the side of the impeller nearer the lower stage, which makes the thrusts of the several stages cumulative. In some pumps the thrusts are made to approximately balance by conducting the water to the further side of the next higher impeller; which causes a more complicated construction of passages in the casing (American Well Works, Allis-Chalmers "Hydraucone" pump), or involves the use of a loop of connecting pipe outside the casing (Dayton-Dowd Type TU). In the "Economy," two pumps are mounted on a single shaft with impeller suctions pointing in opposite directions, and are connected by a loop of pipe.

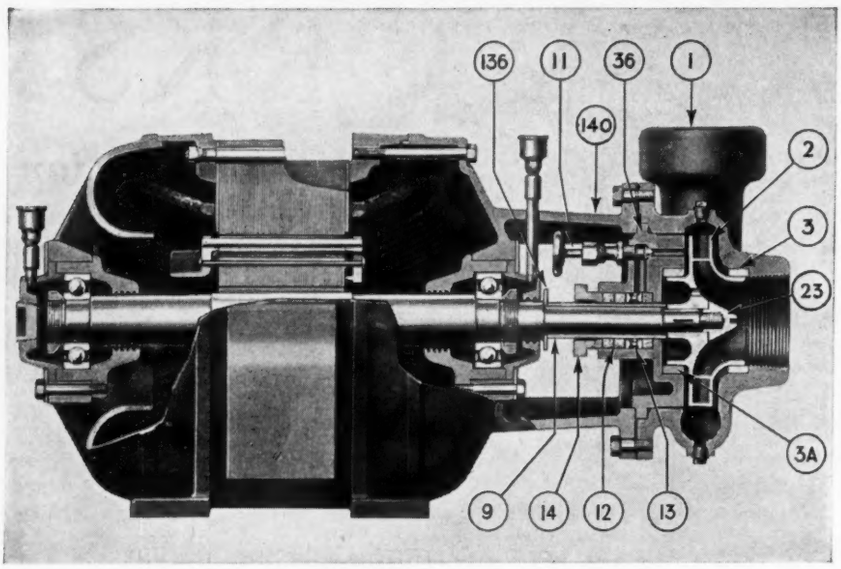
Where the thrusts are approximately balanced, a thrust collar bearing of babbit metal (Dayton-Dowd), of the pivoted bearing shoe type (Allis-Chalmers), or thrust ball bearings (Fairbanks-Morse) are sufficient to maintain the balance. Where the thrusts are unbalanced, a balancing disc is used by Allis-Chalmers, Dayton-Dowd, Dean Hill and others. This consists essentially of a disc attached to the shaft and subjected to the discharge-water pressure on the face facing the suction end of the pump, whereby this pressure counteracts that of the suction. The area of the disc under pressure is sufficient to more than counteract the suction thrust, and this causes the disc (and the shaft) to move slightly longitudinally, which increases an offsetting pressure on the other side of the balancing disc until all pressures are balanced.

Water Passages

A large part of the 25% to 50% increase in efficiency of centrifugal pumps which has been made during recent years has been due to the gradual evolution of design of the water passages in the casing and the impellers, so that the water enters the suction with a velocity of 3 to 8 ft. per second, which velocity is increased rapidly but uniformly as it passes to and through the impeller to that caused by a revolution of 1000 to 3500 rpm, and is then reduced to 3 to 6 ft. per second when it reaches the discharge pipe, or the suction of the next impeller in case of a multi-stage pump. This change of velocity and of direction is effected by means of such easy curves, gradually increasing or decreasing stream flow areas of the volute and other parts of the casing through which the water passes, and



Flat efficency curves with maximum of 87%, and maintained, through a range of 50% of its nominal capacity, over 80% and 85% respectively.



Motor driven, close coupled unit. End suction. For sizes up to 5" x 4" Allis-Chalmers SSU unit.

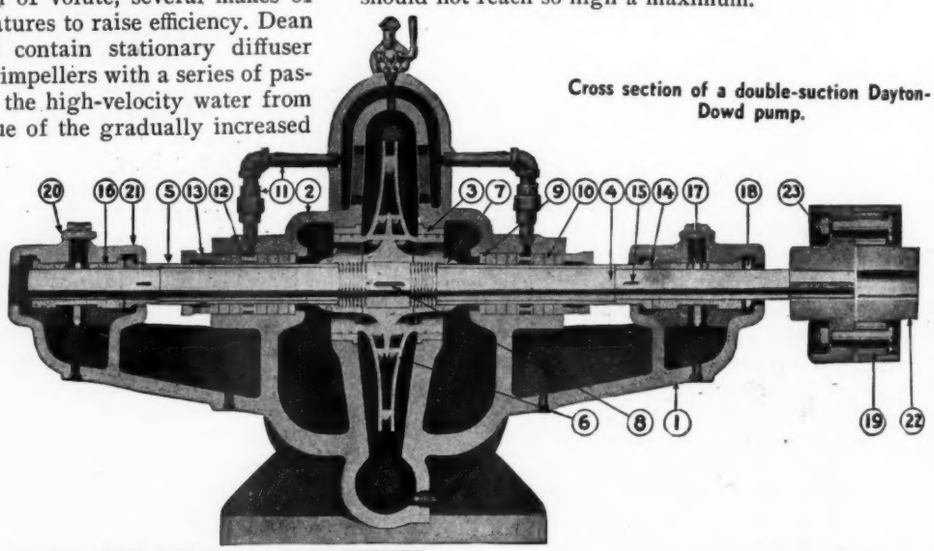
smooth surfaces, that in a high-efficiency pump only 5% or 10% of the energy imparted to the pump is lost by these changes in water velocity and direction. Refinement of construction of water passages accounts for much of the difference between high and low efficiencies.

Aside from mere form of volute, several makes of pumps contain special features to raise efficiency. Dean Hill multi-stage pumps contain stationary diffuser rings which surround the impellers with a series of passageways which "receive the high-velocity water from the impeller and by virtue of the gradually increased areas of the passage-ways reduce the high velocity into pressure." In Buffalo pumps a clearance ring in the casing surrounds the impeller inlets, to prevent leakage and maintain high efficiency.

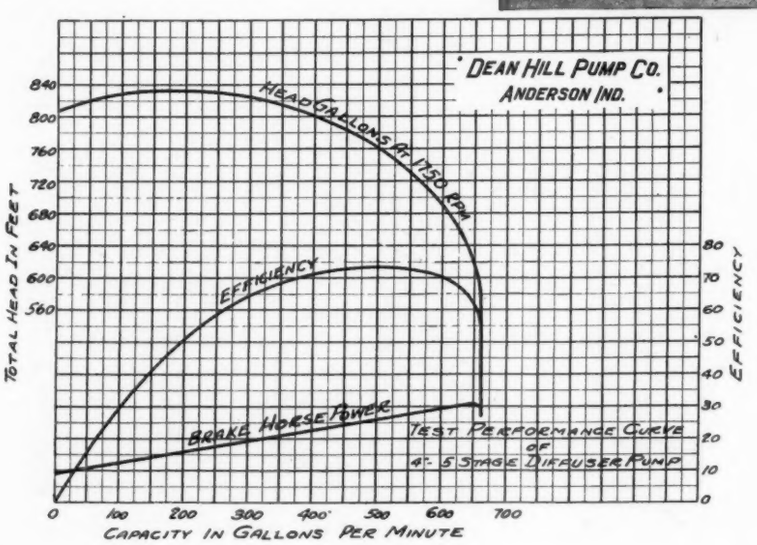
Pump Efficiency

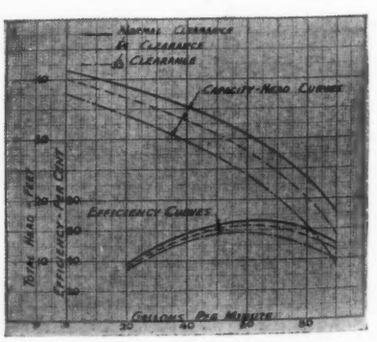
Each centrifugal pump has its maximum efficiency at a certain combination of quantity pumped and head pumped against, and the efficiency falls off more or less rapidly if either of these be increased or decreased. In some pumps the efficiency drops rapidly with slight variations, but a pump can be made so adjusted to the particular conditions under which it is to operate that it will hold up its efficiency quite well under considerable variation of head. In general, a high maximum efficiency can be obtained where the range of variation is narrow, as where pumping is into a reservoir at a uniform rate and head. But for a direct supply for varying consumption, a flatter efficiency curve would be desirable even though it should not reach so high a maximum.

Cross section of a double-suction Dayton-Dowd pump.



1—Lower Case
2—Upper Case
3—Case Wearing Ring
4—Shaft
5—Shaft Sleeve
6—Impeller
7—Impeller Nut
8—Impeller Key
9—Stuffing Box Bottom
10—Packing
11—Water Seal Piping
12—Water Seal Ring
13—Packing Gland
14—Thrust Collar
15—Thrust Collar Key
16—Babbitt Bearing
17—Oil Ring
18—Oil Guard
19—Coupling Bushing
20—Oil Hole Cover
21—Bearing Cap
22—Coupling
23—Coupling Pins

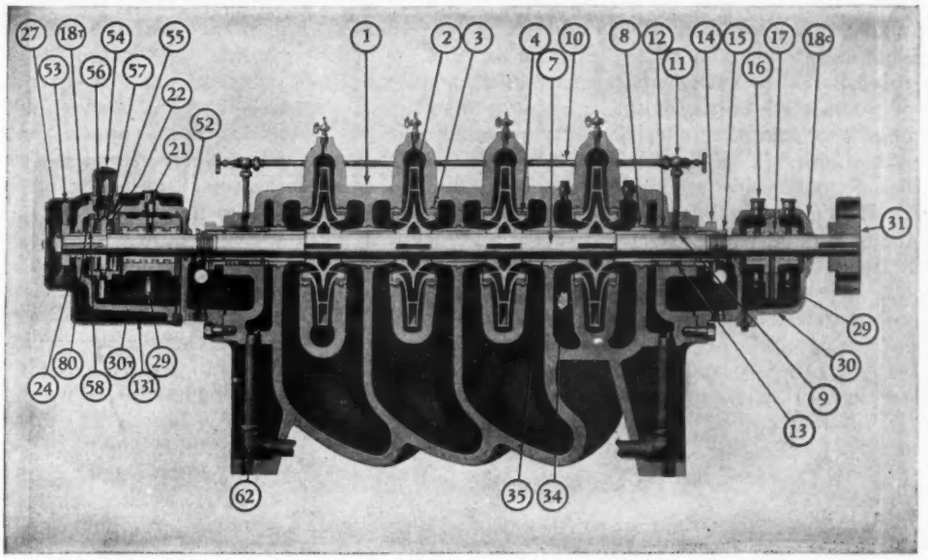




Effect of changing capacity of a pump by use of three different impellers in the same casing.

At left—Test performance curve of pump designed for 500 gpm against 750 ft. total head, with guaranteed efficiency of 72%.

1—Casing
2—Enclosed Runner
3—Casing Wearing Ring
4—Runner Wearing Ring
7—Shaft
8—Stuffing Box Bushing
9—Shaft Sleeve
10—Waterseal Piping
11—Waterseal Valve
12—Packing
13—Waterseal Ring
14—Gland
15—Shaft Sleeve Nut
17—Bearing Shell
18—Bearing Cap
21—Thrust Bearing Shell
22—Thrust Sleeve
24—Oil Slinger
27—Retaining Nut
29—Oil Ring
30—Lower Half Bearing Housing
31—Pump Half Coupling
34—Interstage Bushing
35—Interstage Shaft Sleeve
49—Bearing Lagging
52—Cork Oil Retainer
53—Cooling Fan
54—Oil Vent
55—Kingsbury Housing
56—Thrust Bearing Shoe
57—Thrust Shoe Retaining Ring
58—Adjusting Ring
62—Pressure Equalizing Piping
80—Lock Clip
131—Bearing Jacket



Multi-stage pump with double suction balanced runners and spiral volute passages, Allis Chalmers Co.

In selecting a centrifugal pump, therefore, not only maximum efficiency should be considered, but average efficiency throughout the range of the service for which it is obtained. Pumps are now obtainable with maximum efficiencies of 78% to 82% for small sizes and with higher efficiencies as capacity increases. An efficiency over 90% was obtained in a Chicago pump of 50 mgd capacity against 136 ft. head. It is possible to change the impeller of a pump, using the old casing, and so change the pump characteristics. This might be worth while if an early change in head (as by building an elevated tank) or increase in consumption were expected, the casing being selected to give maximum efficiency to the permanent impeller, while the first temporary impeller would give higher efficiency under the early temporary conditions than the permanent one would. In addition to test efficiency, sustained efficiency (minimum wear, chiefly) and freedom from mechanical trouble require excellence and appropriateness of materials used as well as of design. Accessibility is desirable, although not so important as when pumping sewage or other dirty water.

Special pumps are made for the special service demanded of fire pumps. "In an emergency, often after long periods of idleness, fire pumps must be instantly and unfailingly ready to operate at full capacity and pressure in order to prevent loss of life or serious damage to property." (Fairbanks, Morse & Co.). A national standard for fire pumps has been adopted by the National Board of Fire Underwriters, and any pumps bought for such service should at least meet these specifications.

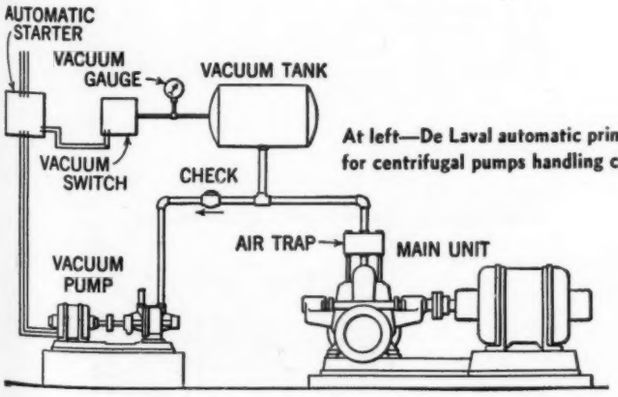
Some Other Features

Given sufficient capacity, reliability and efficiency, there are a number of details of construction which serve durability, convenience, economy of space, appearance, and other desirable features.

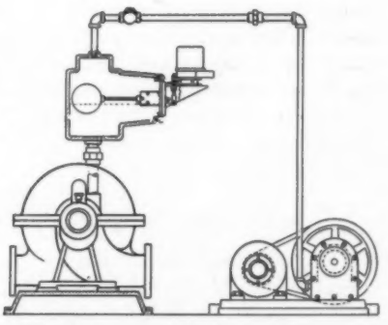
Practically all modern horizontal pumps, except the end suction, have the casing split in two on a horizontal plane passing through the centre of the shaft, so that removal of the upper half gives full access to all impellers, bearings, stuffing boxes and other parts subject to wear or otherwise needing attention. The top must be returned *exactly* to place and bolted there, and dowels, fit-bolts or other means for insuring this are generally provided.

To facilitate removal of the top half, both suction and discharge pipes are generally attached to the bottom half casing. The suction may rise vertically into the bottom if necessary, but is generally horizontal on the right side. (Most manufacturers make their pumps regularly to revolve clockwise when looked at from the power end of the shaft, although the reverse can be had if necessary.)

Except for the largest pumps, the bottom part of the casing, including the suction and discharge and their flanges, is all cast in one piece. This makes for rigidity and durability, absence of joints where leakage might occur, and other advantages.



At left—De Laval automatic priming system for centrifugal pumps handling clear water.



Self-primer operated by vacuum pump driven by independent motor. "Chicago" double suction pump.

In many cases both pump and its motor, whether electric, internal combustion or steam turbine, are provided bolted to a single base, thus insuring exact and permanent alignment of shaft. Some small pumps are built as a part of an electric-motor-operated unit. The Allis-Chalmers SSU unit has a single-stage pump bolted to the side of an electric motor with a single shaft serving both. In the Deming "Motormount," the pump and motor are close coupled and mounted on a substantial base plate the pump shaft being bored out for a split, long-tapered bushing which fits on the motor shaft; pumps up to 4″ size being so combined. When the shafts of the pump and its motor are connected, this is commonly by means of flanges which are not quite brought into contact and are provided with rubber-bushed coupling pins, giving a slight flexibility.

Priming

A centrifugal pump must be fully primed before the driving motor is started in order to avoid injury to, or even the seizing of, wearing rings, and other parts by running dry. Priming may be accomplished either by providing a foot valve in the suction line and filling the pump and the suction pipe with water from an outside source (such as by a feed line from the discharge main); or by exhausting the air from the pump and suction pipe by means of an ejector or vacuum pump and so sucking up water from the pump well (keeping the valve in the discharge line at the pump closed), the ejector being operated by air, steam or water pressure. In the former method, the foot valve may stick or otherwise leak and is generally inaccessible, and its presence at all times causes additional friction in the suction line. The steam or water ejector method, drawing from the top of the pump casing or suction high points, is quite commonly used.

A small vacuum pump instead of an ejector has advantages, and may be operated by an independent motor, or by that which operates the pump. Where air is apt to accumulate in the pump, a vacuum pump which automatically operates to prevent this is an advantage. The Chicago Pump Co. furnishes a self-primer in which an air chamber is placed on the pipe line between the pump and the vacuum pump, which chamber is kept half-full of water by the vacuum, a float in it starting and stopping the vacuum pump as this water falls or rises. In the De Laval automatic priming system the general principle is the same, there being in addition a vacuum tank so that the vacuum pump will need to be operated only intermittently, being stopped and started by means of a vacuum switch. The "Hazleton" suction line primer combines a primer, check valve and strainer; it contains an air chamber which receives air from the suction pipe when the pump starts, stops the pump by means of a mercoid switch when full of air, refills with water and then starts the pump again. and repeats this until all air has been exhausted from the suction.

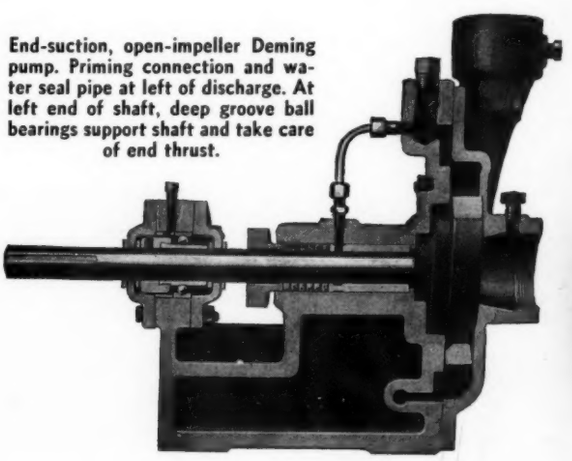
Crispin turbine valves, which permit air to pass through but no water, are furnished for use with automatic priming systems.

Hints on Design and Installation

Total suction lift, including pipe friction, should never exceed 22 ft.—less for high altitudes. The basis for guaranties by pump companies is usually made 15 ft. suction lift, such lift being defined as "the vertical distance from the source of supply, when pumping required capacity, to center of pump, plus velocity head, plus entrance, friction and velocity losses, but not including internal pump losses." All friction should be reduced to a minimum in the suction pipe, which should be as short as possible, with flaring intake, and at least as large as (preferably larger than) the discharge pipe. The bell end of the suction should be such that the velocity of entrance will not exceed 4 ft. per second at normal pump capacity. A strainer is desirable if there is any possibility of solid matters reaching the suction pipe, and should have a total opening at least 1½ or 2 times the area of the suction, preferably larger. (The Rife strainer has area totaling 12 times the pipe area.) Joints should be eliminated or every care taken to make them air tight. (Leakage of 1% air by volume will reduce the capacity of the pump 10%, and 3½% will unprime it.) If it is not vertical, the suction pipe should slope continuously upward to prevent air pockets. The bottom of the suction pipe should be at least 4 ft. below the surface of the water, and more for large pumps.

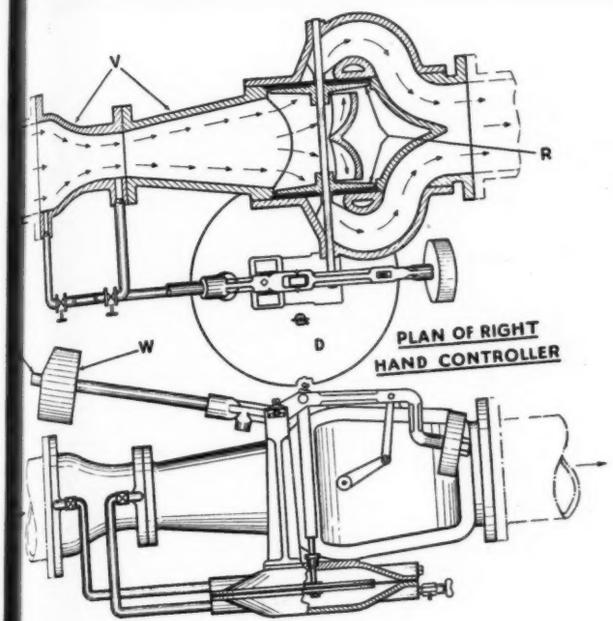
The discharge line should never be smaller than the pump discharge and preferably one or two sizes larger, in which case the increaser should be attached directly to the pump. A check valve should be placed in the discharge close to the pump, with a gate valve beyond it. Especially if the discharge pipe is large, do not bring any of its weight upon the pump but support it independently.

The foundation should be solid and rigid to support the complete unit without deflection, and heavy enough to be free from vibration. A solid concrete foundation on a secure base makes the best support. (Misalignment, which may be caused by foundation weakness, is the most frequent cause of pump trouble.) The top of the concrete should be left approximately one inch low and rough. The foundation bolts are set in the concrete, preferably in pipe sleeve-type holders, according to a template or the exact dimensions furnished by the manufacturers. When the pump is placed on the foundation it should be raised about an inch above the concrete by means of steel or cast iron wedges under the base plate near each bolt and adjusted to bring the pump and driver shafts level and in exact alignment and the suction and discharge flanges exactly vertical (or horizontal). The coupling faces should never touch, but should have sufficient clearance to allow axial movement to both pump and driver shaft to the full thrust clearances. Then pull down firmly on the foundation bolts. Wet the foundation, build a dam or form around it and pour in sufficient 1:1 cement grout to rise ½″ to 1″ above the bottom edge of the base.

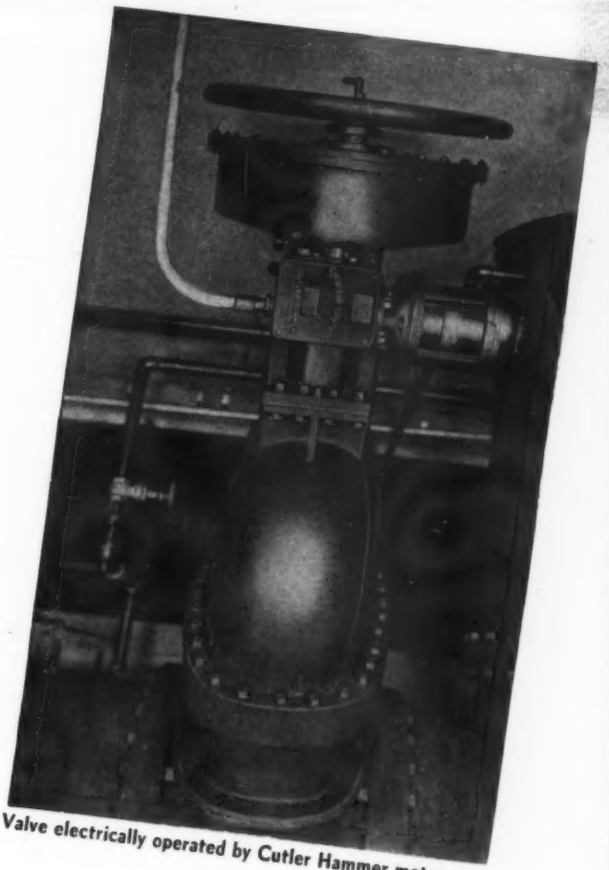


End-suction, open-impeller Deming pump. Priming connection and water seal pipe at left of discharge. At left end of shaft, deep groove ball bearings support shaft and take care of end thrust.

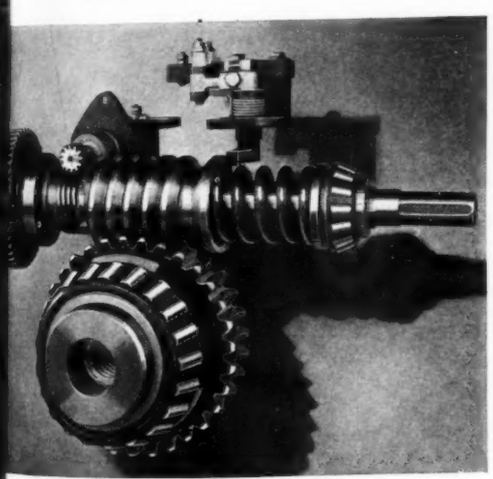
Modern Equipment for Automatic Control in the Water Works Plant



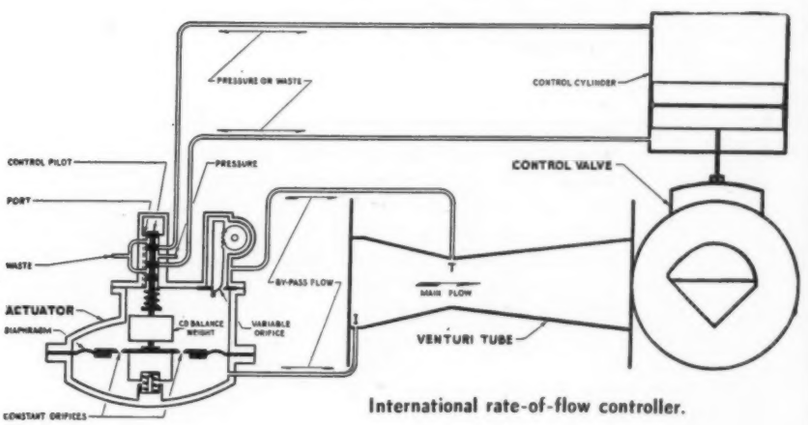
Venturi direct-acting controller. D—diaphragm. R—double-disc balanced rotary valve. S—graduated scale beam carrying weight W.



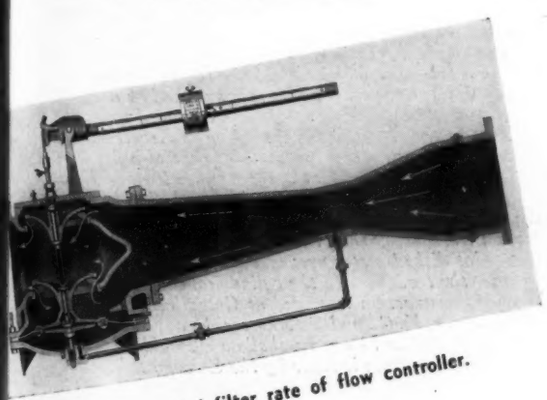
Valve electrically operated by Cutler Hammer motor unit.



Limitorque valve-operating mechanism.



International rate-of-flow controller.



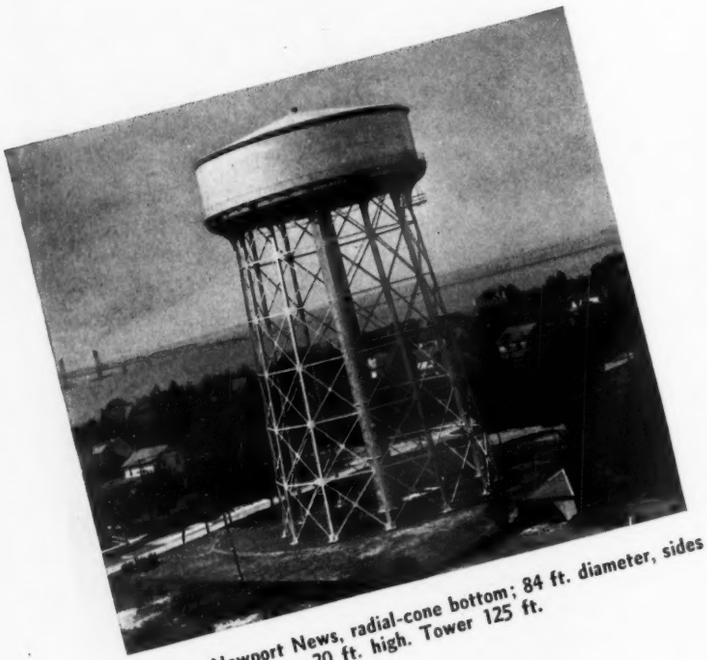
Simplex standard filter rate of flow controller.

Referring to the Illustrations on This Page:

The electrically operated valve above shows the operating motor and reduction gears enclosed in a casing, with wheel for hand operation when desired. The object of the "Limitorque" is to limit the torque that can be applied to the valve-operating parts so as to prevent breakage or strain; when the valve is seated, the worm slides along its shaft against a spring and pushes a lever, which breaks the electric circuit, the adjustable position of the lever determining the seating pressure exerted.

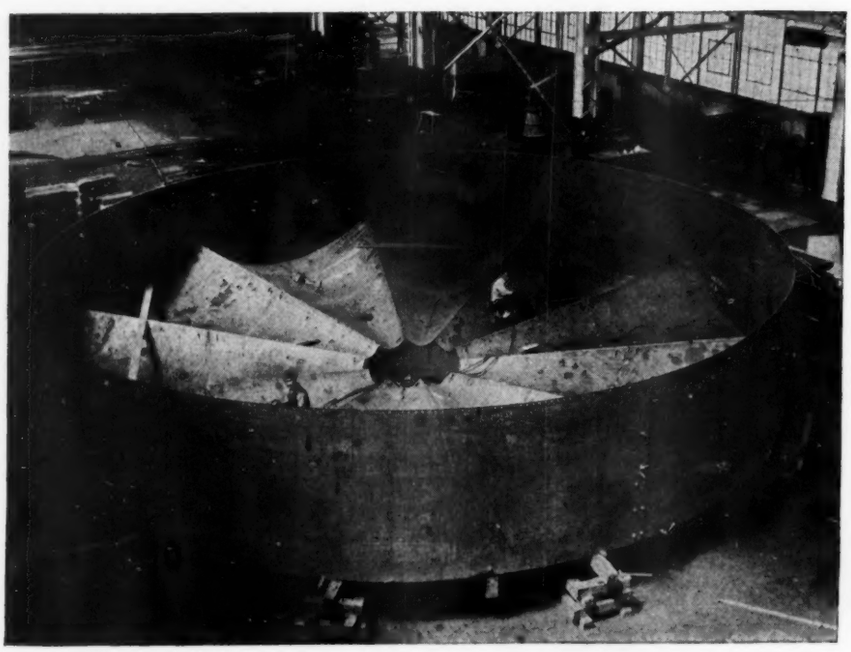
The three rate-of-flow controllers each uses the diaphragm which receives pressure from a venturi throat on one side and from the main line on the other; the motion of the diaphragm operating the valve directly in the Simplex and Venturi controllers, and by pressure lines and a control hydraulic-cylinder in the International.

Designs used in recently c



Tank at Newport News, radial-cone bottom; 84 ft. diameter, sides 20 ft. high. Tower 125 ft.

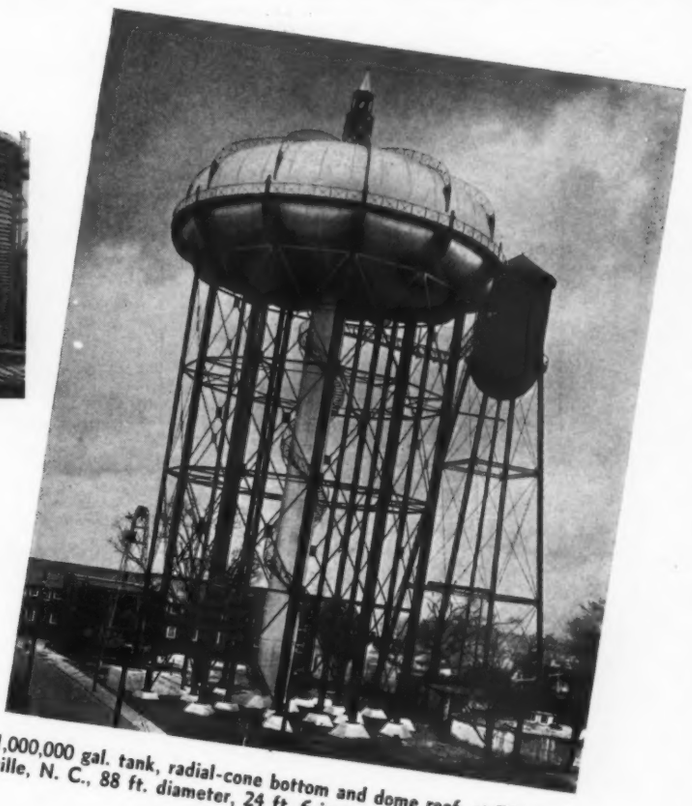
Wash water tank at Dallas, Tex.; 80,000 gal. capacity; diameter 32′, depth of water 16′ 2″. Ellipsoidal bottom. Pittsburgh Des Moines Steel Co.



RADIAL CONE BOTTOMS—*This type of bottom consists of a series of radial conical trough sections connected to radial girders, each girder being supported by the central riser pipe and by one or more posts. The stress in a bottom plate depends upon the radius of the cone of which the bottom plate is a portion. This radius may be increased or decreased by changing either the number of troughs or the depth of the troughs between girders. It is this flexibility which makes it possible to build a tank of large capacity having a very shallow bottom. When the radial conical troughs are extended to an intersection with the cylindrical shell of an elevated tank, the appearance is much the same as that of a flat bottom tank on a tower. This appearance has been modified in several instances by the following method: The truly conical portion of the bottom extended to a diameter several feet smaller than the diameter of the shell. From this point dished plates curved outward and upward to connect the troughs with the cylindrical tank shell. This type of construction was used at Columbus, Evanston, Thomasville, N. C., and Tallahassee. In appearance this bottom is similar to a very shallow ellipsoidal bottom. This type of bottom is made by the Chicago Bridge and Iron Works.*

tly constructed water tanks

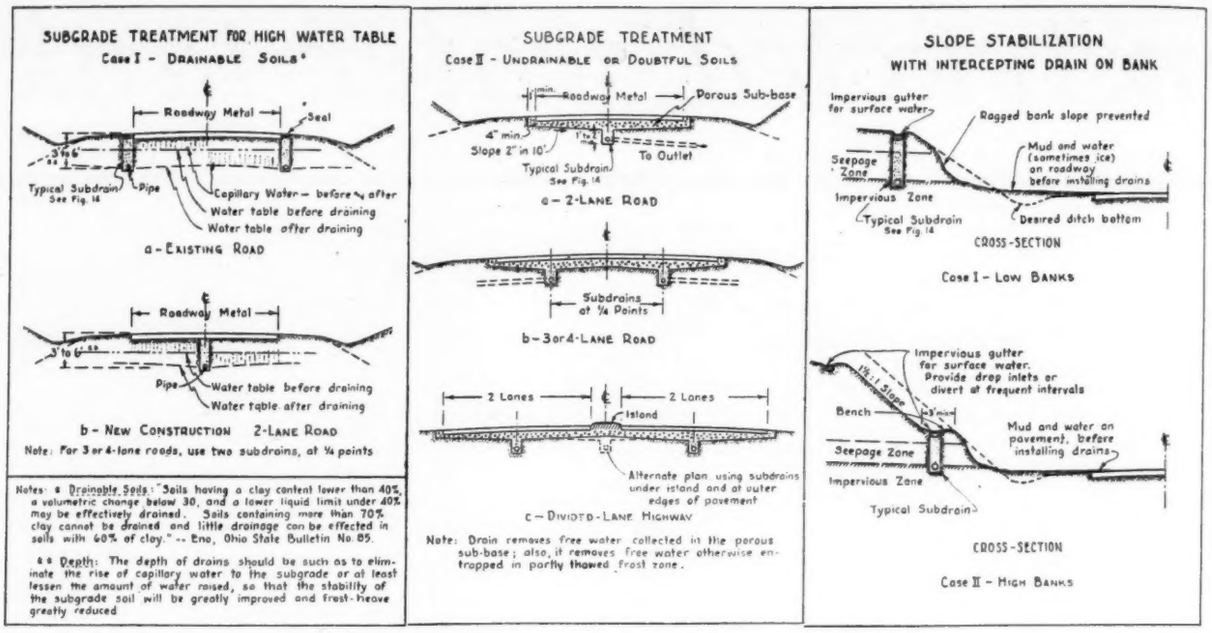
Concrete tank 75 ft. diameter being built at Topeka, Kas., by the Hewett system, the reinforcing hoops being put under stress by means of turnbuckles.



1,000,000 gal. tank, radial-cone bottom and dome roof, at Thomasville, N. C., 88 ft. diameter, 24 ft. 6 in. total water depth. Tower is 115 ft. high.

The new elevated tank at Spartanburg, S. C., 87 ft. diameter, 41 ft. depth of water. Ellipsoidal bottom. Inset shows supports and general appearance.

Torroidal bottom tank, 1,000,000 gallons capacity. Diameter 71 ft., depth of water 35 ft. The bottom inside the inner circle consists of a flat steel plate supported on steel beams between inner ring of posts and center.


SUBGRADE TREATMENT FOR HIGH WATER TABLE
Case I - Drainable Soils*
Roadway Metal
Seal
Typical Subdrain See Fig. 14
Pipe
Capillary Water - before & after
Water table before draining
Water table after draining
a - Existing Road
Roadway Metal
Pipe
Water table before draining
Water table after draining
b - New Construction 2-Lane Road
Note: For 3 or 4-lane roads, use two subdrains, at ¼ points
Notes: * Drainable Soils: "Soils having a clay content lower than 40%, a volumetric change below 30, and a lower liquid limit under 40% may be effectively drained. Soils containing more than 70% clay cannot be drained and little drainage can be effected in soils with 60% of clay." -- Eno, Ohio State Bulletin No. 85.
** Depth: The depth of drains should be such as to eliminate the rise of capillary water to the subgrade or at least lessen the amount of water raised, so that the stability of the subgrade soil will be greatly improved and frost-heave greatly reduced
SUBGRADE TREATMENT
Case II - Undrainable or Doubtful Soils
Roadway Metal
Porous Sub-base
4" min.
Slope 2" in 10'
To Outlet
Typical Subdrain See Fig. 14
a - 2-Lane Road
Subdrains at ¼ Points
b - 3 or 4-Lane Road
2 Lanes
Island
Alternate plan using subdrains under island and at outer edges of pavement
c - Divided-Lane Highway
Note: Drain removes free water collected in the porous sub-base; also, it removes free water otherwise entrapped in partly thawed frost zone.
SLOPE STABILIZATION
WITH INTERCEPTING DRAIN ON BANK
Impervious gutter for surface water
Ragged bank slope prevented
Seepage Zone
Mud and water (sometimes ice) on roadway before installing drains
Impervious Zone
Typical Subdrain See Fig. 14
Desired ditch bottom
CROSS-SECTION
Case I - Low Banks
Impervious gutter for surface water. Provide drop inlets or divert at frequent intervals
1½:1 Slope
Bench
3' min.
Mud and water on pavement, before installing drains
Seepage Zone
Impervious Zone
Typical Subdrain
CROSS-SECTION
Case II - High Banks

Methods of subgrade treatment and slope stabilization are shown above.

Subgrade Drainage for Highways

MOST soils when dry will give adequate support to any reasonable traffic load applied directly or through a pavement. In other words, if a subgrade could be kept continually dry to a sufficient depth, there would be no moisture present to build up ice layers with a resulting frost heave, nor would there be uneven settlement due to loss of support or unequal support which generally results in the pavement breaking under impact of traffic. If kept dry, even the "unstable" soils would be practically harmless.

There are two distinct subdrainage problems; the first may be classified as *interception drainage,* where free water is prevented from entering the subgrade or entrapped water is removed; and the second may be classified as *drainage to control capillary rise,* where by removing free water, the maximum rise of capillary water is controlled. If this distinction is kept in mind, the remedy to be applied can more easily be determined.

Surface or Pipe-Enclosed Ditches

If of adequate size, and of such a gradient that water does not stand in them, side ditches (open or pipe-enclosed) are helpful in lowering the water table in pervious, coarse-grained soils. On the other hand the water level in impervious soils is affected little or none by side ditches.

Should a subdrain pipe be expected to intercept or carry the storm water from the surface? In other words, should a pipe-encased ditch serve both as a subdrain and as a storm water carrier? In general, if the ditch is close to the edge of the pavement, it may be practical to combine the subdrain and the "storm drain," provided, of course, a pipe of ample capacity is used. In this case it is usually well to carry the surface water in a shallow, impervious ditch with drop inlets at frequent intervals, as shown in Fig. 1. If the pervious backfill is carried up to the ditch surface, there is a possibility of it clogging up with dirt from the backslopes.

Where a road has wide shoulders, or where the purpose of the subdrain is to control capillary rise, it is generally not advisable to combine the subdrain with the "storm drain." The reason is that a subdrain placed this far from the edge of the traveled way will not lower the water table under the pavement as efficiently as it would otherwise.

French Drains

A French drain consists of a trench, generally from 2 to 5 feet wide, backfilled with coarse rock, ranging up to one-man size. (Generally no pipe drain is included.) The purpose of French drains is to provide a pervious "wall" for intercepting free ground water. They are used extensively as "bleeders" on many roads, serving to prevent surface erosion, and to stabilize embankments, but they are of limited durability and economy. They are effective for a time, but their maintenance is expensive. The railroads after using them extensively for many years are generally discarding them and using pipe subdrains. This and other drain types are shown in Fig. 2.

Pipe Subdrains; Underdrains

A pipe subdrain or underdrain (also called "side-drain" if located at the side of the road) consists primarily of a pipe placed in a trench that is backfilled with porous or pervious material for the purpose of intercepting underground water or lowering the water table. The pipe admits the water readily and serves as a channel for the free flow of the water to a suitable outlet. There may be deviations from this definition where the pipe is not surrounded by a very pervious material or where the pipe drains a larger area than a trench, such as a sub-base.

In contrast to this type of subdrain, the drain pipe used for farm subdrainage is not ordinarily backfilled with pervious material, the natural soil being used for this purpose. Furthermore, farm subdrainage is gen-

erally placed at such a depth (2½-4 feet) that the capillary "fringe" or maximum rise reaches near the surface or lies within the root area, thus furnishing a usable water supply for the plant roots. Highway subdrainage is radically opposed to this in that the capillary fringe should be a foot or more below the subgrade level. Experience indicates that by placing the highway subdrain at a depth varying from 2½ to 5 or 6 feet, the water table will in most soils be sufficiently lowered to bring the capillary fringe below the point of danger.

Probably a larger percentage of subgrade soils can be successfully subdrained than is thought possible at the present time. For the dense, tight soils, pervious sub-bases or some other treatment is recommended, although generally with some provision for drainage.

Designing the Subdrain—Location and Depth

The first step in designing a subdrain is to locate the ground water causing the trouble and determine the source of water or the direction in which the water table or seepage plane slopes. In some cases the amount or flow of water can be measured, although this is not always important. Spring is generally the best time of year to locate the ground water.

The second step is to observe the character of the soil to whatever depth seems essential to the proper location of the sub-drain. This depth may be a few feet or it may be more. A 1½-inch soil auger with suitable extensions will usually give the necessary information, although in some cases a trench or test pit is desirable.

As previously mentioned, the problem consists of determining whether *interception drainage* or *drainage to control capillary rise* is necessary. If interception is the remedy, the subdrain should extend down to the impervious stratum—one line of pipe generally being sufficient as shown in Figs. 1 and 3. If lowering the water table is the remedy, the depth and spacing of the subdrains must be based on a study of local conditions. On new construction of a two-lane roadway, a single line of pipe under the center line of the road may be sufficient. In other cases and on old construction, two parallel lines of pipe spaces 20 to 40 feet apart may be advisable.

Size of Subdrain Pipe

Theoretically the size of a subdrain pipe can be determined by finding the difference between local rainfall and runoff values. However, experience shows that a 6-inch diameter pipe is generally a practical *minimum*, although 8-inch diameter is the standard minimum in some localities. Furthermore, where subdrainage lines do not exceed a few hundred feet in length, a 6 or 8-inch diameter is amply large. Where surface water is admitted, proper allowance should be made to accommodate it as well as the ground water.

Slope of Pipe

The slope of the subdrain pipe will usually be controlled by local topography. However, a minimum recommended slope of such a pipe is 0.5 per cent, (6 inches per hundred feet), and a greater fall is preferable. A slope of 0.1 per cent has been known to be satisfactory, but this does not allow much of a factor of safety in case of settlement of the subdrain, and very careful laying is necessary.

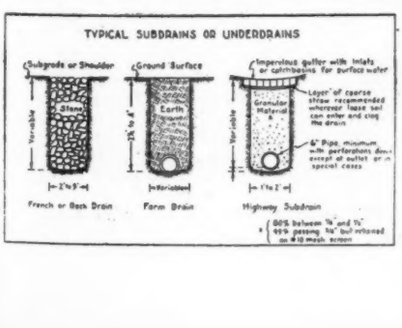

TYPICAL SUBDRAINS OR UNDERDRAINS
Subgrade or Shoulder
Ground Surface
Impervious gutter with inlets or catchbasins for surface water
Stone
Earth
Granular Material
Layer of coarse straw recommended wherever loose soil can enter and clog the drain
6" Pipe, minimum, with perforations down except at outlet or in special cases
French or Rock Drain
Farm Drain
Highway Subdrain

Fig. 2 Typical subdrain.

Fig. 1 Shallow ditch with underdrains.

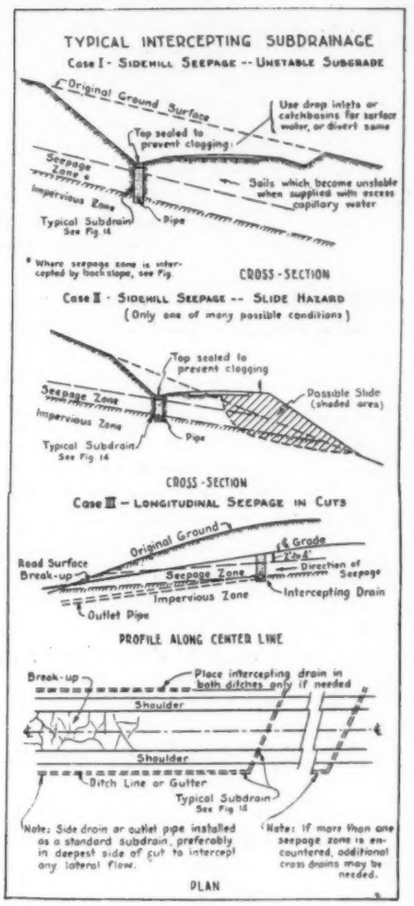

TYPICAL INTERCEPTING SUBDRAINAGE
Case I - Sidehill Seepage -- Unstable Subgrade
Original Ground Surface
Use drop inlets or catchbasins for surface water, or divert same
Top sealed to prevent clogging
Seepage Zone *
Impervious Zone
Soils which become unstable when supplied with excess capillary water
Typical Subdrain See Fig. 14
Pipe
* Where seepage zone is intercepted by back slope, see Fig.
CROSS-SECTION
Case II - Sidehill Seepage -- Slide Hazard
(Only one of many possible conditions)
Top sealed to prevent clogging
Seepage Zone
Impervious Zone
Possible Slide (shaded area)
Typical Subdrain See Fig. 14
Pipe
CROSS-SECTION
Case III - Longitudinal Seepage in Cuts
Original Ground
℄ Grade
Road Surface Break-up
Seepage Zone
Direction of Seepage
Impervious Zone
Intercepting Drain
Outlet Pipe
PROFILE ALONG CENTER LINE
Break-up
Place intercepting drain in both ditches only if needed
Shoulder
Shoulder
Ditch Line or Gutter
Typical Subdrain See Fig. 18
Note: Side drain or outlet pipe installed as a standard subdrain, preferably in deepest side of cut to intercept any lateral flow.
Note: If more than one seepage zone is encountered, additional cross drains may be needed.
PLAN

Fig. 3 Sidehill seepage.

Fig. 4 Seepage in cuts.

Outlet of Pipe; Upper End

Briefly, the outlet of a subdrain pipe should be high enough above its surroundings that it will not clog up. In order to provide a suitable outlet and still give the pipe ample slope, it may be necessary to carry the pipe a longer distance.

The outlet end of the pipe should be covered with a suitable screen to prevent rodents from clogging the pipe with their nests.

Ordinarily the upper end of the pipe is closed by means of a plug or cap to keep the soil or backfill out. However, the theory has been advanced that the upper end of a subdrain should be extended to open air, thus giving beneficial ventilation to the subdrain and the soil surrounding it. At least several installations lend credence to this theory.

Openings in Pipe

With exceptions that will be noted, the perforations in the subdrain pipe should be placed *downward* or in the lower half of the pipe. Research shows that in this position the water table is lowered quicker and to a greater depth than if placed upward; also, silting is practically eliminated.

However, where there is a danger of losing the water as in crossing pervious areas or water pockets, or wherever the pipe serves merely as a carrier, it is advisable to have the perforations up or use a tight pipe in those places. This is also true of the outlet end of the pipe.

Trench and Backfill

The width of a subdrain trench is partly controlled by the size and depth of the pipe, the idea being to give sufficient working room in the trench to joint up the

pipe. Usually a width of 12 to 18 inches is ample for practical purposes.

The backfill surrounding the pipe should ordinarily be a "bank-run" gravel or its equivalent, the bulk of the material ranging from ¼-inch to ½-inch in size, at least for a distance of 6 inches over the pipe. Above that point, coarser material may be used. The theory is that a fine, graded material will serve to keep out the silt and at the same time be amply permeable; also it reduces erosion in the walls of the trench. Placing a few inches of pervious material under the pipe is in most cases recommended in order to facilitate infiltration and to keep the pipe out of the soft soil.

Stabilization of Fills

Proper methods of constructing and compacting embankments will do much to eliminate unequal and continued settlement over a period of years. In some instances the removal of muck or unstable foundation soils is necessary before a fill can be made, although cases are recorded where ditch and pipe subdrainage have stabilized the foundation.

Where frost heaves occur on fills or where slumping occurs, stabilization is necessary. Here again, the source of the water must be determined and then removed as already described. Water pockets can be tapped, either by open trenching or using the "boring machine" to place laterals at frequent intervals. In perhaps a few cases, drains paralleling the roadway will be found more suitable than the use of laterals.

These data and the accompanying illustrations are taken from a publication, "Subgrade Drainage for Modern Highways," just issued by the Armco Culvert Mfrs. Association. Copies of the publication will be sent on request.

Penetration of Moisture Through Masonry Walls

Rates of penetration of moisture through walls of brick masonry are being measured by the U. S. Bureau of Standards to determine what combinations of materials and types of construction are most resistant to leakage when exposed to rainfall. The walls are about 50 inches high, 40 inches long, and either 8 or 12 inches thick, according to the Journal of the Franklin Institute. Each of the specimens differs from the others with respect to thickness, kind of brick or mortar, or quality of workmanship. Included are walls of each of three kinds of brick, four mortar compositions, and two qualities of workmanship. In the walls of class A workmanship, the joints are well filled with mortar, the method employed by the mason being similar to that described in specifications for high quality masonry. Class B workmanship is intended to be similar to that used in the construction of buildings where inspection is lacking; the interior joints are not filled and the mason does not attempt to use more mortar than is required for an acceptable appearance.

Although the walls are to be tested also under conditions resembling exposure to strong wind and heavy rain, the data available now are largely the results of tests in which the water penetrates under the forces of capillarity and of gravity only. Water is applied by means of a spray at the top of a wall, causing the formation of a continuous film of water on the exposed face of the wall. Observations of the performance of a wall under test include the time for dampness first to penetrate through the wall, the rate of leakage, and the amount of water absorbed during a test.

The results of the tests indicate that, for walls of equal thickness, the quality of workmanship has a major influence on the rate of penetration of water. None of the walls of class A workmanship has leaked, whereas all of those with class B workmanship have allowed water to pass in measurable amounts. When dampness penetrated walls of class A workmanship, the moisture apparently was transmitted by capillarity. With the nearly non-absorptive brick, moisture penetration was more rapid in the mortar than in the brick; with the more absorptive ones it was more rapid in the brick. The greatest leakage occurred with walls of bricks of low absorption and class B workmanship. The data obtained thus far do not show how the composition of the mortar may affect the permeability of walls. They indicate, however, that the quality of the workmanship and the thickness of the walls have a greater influence on permeability than any of the other variable factors under study.

Vibrating Concrete on New York City Bridge

The two photographs herewith show the construction of a concrete slab on the Williamsburg Bridge, New York City. This is of interest because of the methods used for placing the concrete in the close reinforcement of this pavement.

The slab is 18 feet 3 inches wide and is reinforced with 4-inch bar trusses spaced 6 inches on centers. A white cement traffic marker 4 inches wide is placed just before the surface is completed.

Munsell concrete vibrators type E model are being used to consolidate the concrete as it is placed, also two vibrating screed boards with three Munsell vibrators on each, spaced approximately at the quarter points are used to strike off and vibrate the surface of the slab. In operation, the screed boards are applied approximately one half hour after the concrete is placed with one pass of each screed board as the work progresses.

These illustrations show concrete slab construction, using concrete vibrators, on the Williamsburg Bridge, in New York City. Note the closely spaced reinforcing at the left.

The Editor's Page

Water Treatment Development Needed

Advancement in the science of sewage treatment has been very rapid in the past few years, with most decided emphasis on the chemical-mechanical phases of treatment. In perhaps five years, the industry has been placed on nearly a new basis. Much of this advance has been due to the initiative and the ability of the manufacturers of sewage treatment apparatus.

It has been many years since the water treatment industry has made any radical advance or progress. The mechanical filter has continued for forty years to treat water satisfactorily; but there is lots of room for advancement.

The present cost of such filters is a handicap to those communities that have a brief seasonal period when filtration would be desirable. There is a tremendous need and a place for low-cost filters for small and medium-sized communities. In most cases, the need is for an efficient strainer rather than a complicated filter, though ability to use the equipment as a filter for brief periods is desirable.

A filter capable of handling four or five gallons per square foot per minute, with or without coagulants (as the condition of the water would determine), requiring a minimum of operating attention and within the financial reach of communities now on or near the border-line of needing filtration, would find a very wide field of usefulness.

If the waterworks industry can match the advance of the sewage treatment industry of the past few years, such a filter (or substitute for a filter) should soon be available to open up a vast new market for many waterworks materials.

Mr. Malthus and Highway Accidents:

A good many years ago a lot of people worried over the Malthusian idea which was, generally speaking, that some time or other there wouldn't even be standing room on the world. As the science of preventive medicine came to the stage of practical application, and the deaths from typhoid fever, diphtheria, scarlet fever, colitis, and what not became such a rarity that the finger of scorn was pointed at any community having an undue number of them, there was an even greater reaction among those folks who enjoy a good steady worry. The average expectancy of life about doubled. It didn't look like the world could ever expect to get rid of a lot of its old fogies.

Our modern combination of good roads, high speed automobiles and insane desires to get somewhere else in less time than nothing flat has changed all that. It has even eliminated the old-time need for a good war every twenty years or so in order to give the rest of us a little more elbow room. About 100 persons per day are being killed in highway accidents; about 300 per day are suffering permanent disabilities; and about 3,000 per day temporary disabilities—a million and a quarter casualties a year.

That's a lot of people, probably more than Mr. Malthus ever saw in his life. What's to be done about it? We have a hunch that no one single brilliant idea or invention will do much good, but that the solution will lie in the weary business of attention to many details—building safer highways; educating and instructing motorists that are able to learn, and retiring from the highways those that cannot or will not; maintaining in safe condition brakes, lights, steering gear and tires; building more roads to deconcentrate traffic; forcing off the roads a lot of over-age automobiles that are unsafe and a menace to everyone in or near them.

The National Safety Council, and a lot of other organizations including our own American Road Builders' Association, are doing a good job on this. A drive to save 38,000 lives by 1940 is on.

Let's all help.

Getting His First Engineering Job

For some months now, young men about to graduate from the engineering schools of the country have been wondering what the future holds in store for them. Getting placed—finding a job—is undoubtedly heavy on the minds of many of them. Soon after this issue reaches our readers, these young engineers will be out in the world—many of them to shift for themselves.

We are not among those who are ready to weep because the youth of today has no chance. We believe that the young man of today has as good a chance as the young men that have gone before him. We concede that it may be difficult to find the initial opening; but we contend that the severer conditions that he will encounter in making his way forward will bring him compensations.

The first thing the man who seeks a position must realize is that the seeking itself is a job and, like any other job, should be given systematic study. Working at the problem of finding a position eight or more hours a day will surely find one. Tentative and aimless efforts won't accomplish much. Canvass the kinds of work you wish to go into, or are willing to accept; and remember that for the first few years it really does not make much difference in what kind of engineering you are engaged; experience in several lines is best.

There are 48 state highway departments; some 46 or 47 state sanitary engineering departments; 1,833 cities of more than 5,000 population, most of which have more or less engineering work to be done; 2,250 counties which have an engineering organization; 700 consulting engineers; innumerable industries of all sorts. Consult your professors; plan your contact work on a wide scale. Don't be afraid to ask for help. Use just as much energy, good sense and technical ability in solving the problem of finding a job as you did in earning your degree. And above all, don't be afraid to work at least eight hours a day—and even "far into the night"—on this, your most important job.

Automatic Pump Control for a Deep Well Supply

EL PASO, Tex., obtains its water supply by means of deep wells which are located in various parts of the city, some within a few blocks of the center of the business district, others as far as seven miles away. All of these wells yield considerable sand during the first year when the pumps (deep-well turbines are used) are stopped and started. For this reason each turbine discharges into a covered concrete basin which serves as a sand trap; from which basins the water is pumped by booster pumps directly into the distribution system, and through this into four covered concrete reservoirs which have a combined capacity of 50,000,000 gallons.

The reservoirs receive the excess pumpage during hours of low consumption, and deliver water into the system during hours of high consumption. During the summer months peak consumption may be twice as great during the early evening hours, when lawns are being watered, as during the rest of the 24 hours.

The head pumped against varies from 30 to 100 pounds, depending upon the elevation and location of the pumping station relative to that of the reservoirs, which are located at the north edge of the city. Each booster pump is designed to handle only the output of its well when it is operating against the highest pressure at that location. A drop of only a few pounds in pressure will cause the booster discharge to exceed the steady flow from the well, and such an operating condition, if continued for a sufficient period of time, will cause the booster to drain the settling basin and either become air-bound and damaged or deliver considerable air to the mains. It is therefore necessary, of course, that the booster pump discharge be controlled in some way.

One group of four wells is equipped with a central booster station. As this station has 24-hour attendance, hand operated control is satisfactory, and automatic control has never been installed. The balance of the wells are widely scattered over the city, each well, pump station and settling basin being located on a 50 x 125 ft. lot. A house also is located on each of these lots, and is occupied by one of the pipe line foremen. However, this foreman is at the station only at night, with the result that the pumps operate most of the time without attendance. All of these stations have been equipped with automatic control for the booster pump discharge.

This automatic control is very simple and effective. A butterfly valve is installed in the discharge piping of the booster pump. A float is installed in the settling basin and operates the butterfly valve through a shaft and links. This float consists of a thirty-gallon hot-water tank whose buoyancy furnishes more than ample power to operate the valve. This device so operates that any change in the water level in the settling basin will change the rate of pump discharge. Even though a main should break nearby, the pump discharge would be brought back to that furnished by the well within a few minutes. A hand-operated valve also is provided, bolted directly to the pump discharge, which is used only when starting and stopping, being left wide open during pumping.

All the booster pumps are equipped with Venturi meters, pressure recorders, electric meters, etc. Comparison of pumping records under manual control in June, 1933, and under automatic control in June, 1935, show the advantage of the latter. In June, 1933, at 6:00 P. M. on Tuesday, the chart indicates that booster pump discharge was at the rate of 2,800,000 gallons per 24 hours. At that time, the operator left the job but, before leaving, cut the flow back to 2,300,000 gallons. Between 6:00 P. M. and 9:00 P. M., the pump operated without attendance. At 9:00 P. M. a new operator came on the job, and he increased the flow to 2,500,000 gallons. From that time until 4:00 P. M. Wednesday afternoon, the valve was not touched, and during that period the flow ranged from a minimum of 2,250,000 gallons to a maximum of 2,900,000 gallons, this variation being due to variation in main pressure. At 4:00 P. M. Wednesday afternoon, the operator cut the flow back from nearly 2,800,000 gallons to 2,400,000 gallons. The pump operated without attendance until 9:00 P. M., at which time the flow was 2,100,000 gallons. The new operator came on at 9:00 P. M., and increased the flow to 2,500,000 gallons.

In June, 1935, during a week's operation under automatic control, the high peaks are slightly less than 1,800,000 gallons, the lows about 1,650,000, with the average about 1,700,000 gallons

The booster pumps are Byron-Jackson make. Simplex meters are used for measuring the discharges. E. Nevins is chief engineer of the El Paso water works.

An Interesting Booster Pump Installation

By H. S. THANE

Superintendent, Missoula Division, Montana Power Co.

WE HAVE a 4-inch main, about 10,000 feet long, that serves a small area comprising some 25 customers, at the end of the line, located considerably higher than the rest of our distribution system. Due principally to the sprinkling load, pressures were very unsatisfactory in this area. In order to supply adequate quantities at satisfactory pressure during the peak sprinkling hours, we installed a 20,000 gallon tank at the ground level at the end of this line.

This tank is allowed to fill during the off-peak hours, and is controlled by a float valve. On the far side of the tank a 7½ H.P., 200-gallon per minute pump is installed, which takes its supply from the tank, and pumps directly into the distribution system serving the area. The characteristics of this pump are such that its maximum pressure is approximately 45 lbs. The main is by-passed around the tank and pump, with a check valve in the by-pass, and the pump controlled by pressure so that when normal pressure is available without the pump it shuts down, but when pressure falls the pump starts.

We had this arrangement in operation during the summer of 1935 and the results were very satisfactory, although, of course, it is not an economical method except in this special case.

Common Salt in Road Stabilization

By DR. C. D. LOOKER,

Director of Research, International Salt Company, Ithaca, N. Y.

Above, a mix-in-place job in Ohio, and below, a York rake taking out the coarse stone on a New York job.

A SOIL-STABILIZED road is one composed of a uniform mixture of coarse and fine aggregate compacted and held together by means of connecting moisture films surrounding the interlocking particles.

The materials of construction most commonly used to secure stability are gravel, crushed stone, slag, sand or stone dust and natural soil binder which includes fine sand, silt and clay. These materials are either premixed or mixed in place in the proper quantities and proportions to give all-weather stability.

Dry clay can not be compacted to as dense mass as moist clay. Compacted dry clay soon loses its densification because the clay particles are held apart by layers of air. Wet or damp clay lends itself to compaction because the air layers have been replaced by films of moisture which not only permit closer contact but resist separation of particles as excess moisture is lost by evaporation. Solutions of electrolytes such as common salt aid in removing air films and wetting soil grains, thus assisting in compaction; and also in retaining moisture.

The value of the greater moisture retentive power, surface tension and electrolytic effects appears to be maintained throughout the life of the road but seems to be most useful during the construction period when the separate ingredients are reaching equilibrium in the interlocked structure of which the compacted mass is composed. These effects are brought about mainly because the soil binder portion of the mix is maintained in the plastic condition for a longer period of time during the period of compaction and setting up.

The salt can not be effective unless it has been made into a brine either after being incorporated with the mixture or prior to its application. Results seem equally good with salt applied dry or as brine. Recent tests have shown that best compaction is obtained if the soil fines passing the 40-mesh sieve contain approximately 15 to 20% moisture, or, in other words, slightly above the plastic limit but lower than the liquid limit. This amount of water is approximately 6% of the completed mix and more than sufficient to dissolve all of the recommended quantity of salt, converting it into brine before ultimate compaction is attained. The amount of salt commonly recommended and used is between 2/3 of a pound and one pound per square yard per inch of thickness. The effect of incorporating this amount of common salt in more than three inches of compacted stabilized mat is being investigated. Indications are that where the thickness is greater than three inches, the additional amount of sodium chloride is justifiable.

If a salt-soil-stabilized road is to be used and maintained as a wearing course, the maximum size of the coarse aggregate should be somewhat smaller and more uniform than if it is to be used as a base course under higher type surfacing. For wearing courses the maximum size of aggregate may be as small as half-inch; not more than 10% should be larger than one-inch. If larger stones appear in the surface, they are apt to become loosened by traffic and be the means of starting potholes. Furthermore, the finer particles continue to compact around the larger stones and cause them to protrude above the surface making the road rough for driving. The same objection will arise by the gradual wearing away of the finer constituents around larger size stones. Under heavy traffic and frequent maintenance some of the softer stones have been known to break into several pieces and eventually be worked out of the stabilized mat.

For base course construction, the State of Indiana limits the size of the stones to that which can be handled without segregation and to the thickness of the course. Their upper limit in the lower layers of the base course is a maximum size of 1½ inches while the top layers are limited to a maximum size of 1 inch.

In all cases there should be only sufficient fine aggregate to provide embedment for the larger particles. Indiana has changed the specifications regarding the plasticity index or cohesiveness of the 40-mesh material from their former requirements of 8 to 14 progressively through a limit of 6 to 11 and finally are permitting the limit of plasticity to a range of 3 to 9. By proportioning the binder soil and all material passing the 40-mesh sieve, so as to give a lower plasticity index, sufficient binding qualities may still be maintained to prevent excessive raveling in dry weather and preserve the bond so that there is less volume change resulting in excessive displacements during long, continued wet weather.

The Indiana specifications call for 15 to 30% passing the 40 sieve and it has been found that 20 to 25% seems to give the best results. Some roads constructed in New York State having percentages of fine soil higher than 40 seem to verify the findings reported by Indiana. One road in New York which had an excessive amount of fine soil proved to be satisfactory during the summer months following construction but softened and rutted badly during the following Spring break-up. When this excess soil binder was treated with clean pea gravel, these difficulties were entirely eliminated. Other projects in New York and Virginia have proven quite satisfactory with plasticity indexes ranging from 4 to 6 when used as wearing surfaces bearing moderately light traffic.

After the material has been placed on the road in such proportions as to give stability when compacted, the surface should be shaped by blading, or otherwise, and moistened sufficiently before compacting. Best results seem to be obtained by compacting the stabilized material in layers not to exceed 3 inches of loose material. The successive layers seem to be compacted most efficiently by means of the rolling and kneading action provided by multiple wheel compactors, trucks, and automobile traffic.

Each layer should be allowed to season for a period before applying the next layer. After the final surface layer has been applied and compacted, care should be taken to maintain the surface in a smooth condition while it is undergoing the setting up and seasoning period. It should be bladed frequently while setting up and compacted by rolling while the mix is slightly above the plastic limit.

During the finishing operations, it is important to maintain the surface as smooth as possible with a crown or slope sufficient to drain excess water from the road. A maximum slope of approximately ½ inch per foot seems to be sufficient to prevent potholing. The slope should be uniform from the center of the road to the outside, except for a slight rounding off at the center. If the center is left too flat, it will tend to pothole, because of the retention of water. On most roads, the center receives the least amount of traffic and is more apt to receive less compaction due to traffic and consequently is more liable to pothole than the other portions of the road receiving constant compaction by the wheels of automobiles.

After the road has set up and become firm, it may be opened to traffic without danger of rutting even during continued wet weather if it has been properly made. If heavy rains occur soon after construction on roads that receive excessive traffic, it may be necessary to maintain the road in a smooth condition during the drying out period. No maintenance of salt-stabilized roads should be carried on except when the surface is sufficiently moist to prevent dislodgment of the embedded material. If, because of excessive traffic, the road surface becomes raveled during dry weather and maintenance seems necessary, it should be done by means of a blade maintainer while the road is wet, or immediately after a rain.

This is an abstract of a paper which was presented at the Nineteenth Annual Convention, National Crushed Stone Association, St. Louis, Mo.

This shows how the bridge described by Mr. Hecathorn at the right was widened.

Lot Cleaning by Highway Department

The Highway Department of Upper Darby Township, Pennsylvania, has taken the position that it is a responsibility of the township to keep high grass and weeds cut along any sidewalk where they would be an inconvenience to pedestrians. All such sidewalks throughout the township were cleared at least twice during the year, and in some cases oftener. On this work a Rawls Model 2 M-motor scythe with 36" blade was used with excellent results. When the amount of work to be done became very heavy an additional machine of the same make was borrowed from the Park Department.

During 1935 the owners of vacant ground overgrown with tall grass and weeds to such an extent as to be a menace to public health were given five days notice to clear their property. At the expiration of that time the Highway Department would cut the grass and weeds and bill the owner with the cost of labor and material plus ten per cent. If the bill was unpaid a municipal lien was filed against the property.

Four hundred and thirty-three such notices were sent out and in two hundred and thirty-three cases the lot was cleaned by the owner. This was a much higher percentage of owner response than in former years, due largely to the fact that a very careful check was made to make sure that the notices and bills were delivered to the proper persons.

A total of $2,061.30 in labor and $97.74 in gasoline and supplies was expended in the work and of the bills sent to property owners the sum of $172.17 remained unpaid at the end of the year.

A Bridge Repair Job

By OTHA HECATHORN
County Engineer, Eaton, O.

Some fifteen years ago, a 34-ft. span concrete girder bridge with 16-ft. clear roadway, constructed from a standard plan and placed on the abutments of an old wood truss bridge, was located at the center of a sharp "S" curve. When it was decided recently to widen and improve the alignment of the roadway, this bridge offered a problem. It was still in excellent condition, and in order to save it, the changes shown in the illustration were made.

A triangular reinforced concrete girder was constructed on each side of the bridge and the old balustrade, sidewalk and curb removed. The illustration shows the right wall and girder in place, and the forms set for the left girder. This construction, which was carried on without material interference with traffic, provided an additional 14 feet of roadway width; with a 3-ft. sidewalk on either side, the clear roadway was 24 feet. The expense of a temporary bridge and roadway was eliminated.

This work was done by force account, using county equipment and under the supervision of the county engineer.

Hazards in Laying Water and Sewer Lines in the Same Trench

By Capt. J. C. Hanes,
Instructor, Dep't. of Civil Engineering, Virginia Military Institute

INVESTIGATIONS show that the practice of laying water mains and sewers in the same trench is common. Three conditions occur in this type of construction: 1. The actual paralleling of lines close together or in the same trench; 2. The crossing of water and sewer lines; 3. The crossing of water and sewer service lines on entering or leaving private property. The greatest offenders are of the last type, because they are so often put in by individuals who use varying degrees of care in construction.

The average homeowner will allow or even encourage the placing of water service and sewer connections in the same trench on entering his property, especially if he can save money by doing so. Water departments or municipalities may feel some hesitation in telling the property owner what he may do on his own property. Yet that which leaves such private property ceases to be private, especially if it is sewage, and in the interests of public health might well be subject to regulation and legislation.

The idea that sewage may enter water lines may be scoffed at by the unthinking, since the pressure in the water line is always higher than the pressure (if any) in the sewer. But is this always true? If a connection or a repair is made to a main, that section is isolated by valves and drained from the lower end. When this happens not only is the pressure in the main released, but there actually may be a suction at the higher end. If the water line has a leak in it, moisture or water around the pipe may be drawn into it, for very few water lines have a zero leakage.

Not a great many sewer lines are tight, especially those that have been in service for several years. Therefore, if a sewer line is in the same trench as the water line, or even within a few feet of it, it is possible, and very probable, that the ground adjacent is or has been saturated with sewage. Moreover, even though the water line is tight, there is abundant opportunity for contaminating the water line during repairs or in the process of making the connection. The cup full of waste water that ran into the water pipe, or the mud smears left by the workmen may carry contamination.

A number of typhoid epidemics have occurred from such causes, notable among them being that at Lexington, Va., in 1910, with nearly 100 cases.

Not only is the sewer dangerous to the water supply, as already pointed out, but the water lines may also be dangerous to the sewer. Because of the high pressure ordinarily used in water lines, a break will almost invariably disrupt the adjacent ground, and if the sewer be very near to the water line, it may break, in which case both water and sewage flood the area, with consequent danger to the quality of the water when repairing the line.

There is also the possibility of considerable loss of water due to a break or large leak in a main, with the water escaping into a nearby sewer. In such cases there are no surface indications of leakage, and the loss may remain undetected for a long time. Moreover, if the water pressure is cut off, a suction may be caused in the water line and the flow may then be from the sewer into the water main. This condition actually occurred in Fairmont, N. D., in 1923, and was the cause of a typhoid outbreak.

Crossing of all water and sewer lines cannot economically be prevented, nor can water and sewer lines be placed other than in the same street ordinarily. But they can be placed in different trenches and sufficiently far apart so that a leak in one line cannot be admitted through a leak into the other. The distance that the lines should be kept apart will vary with the type of soil, whether the pipes are parallel or cross, and the material and method of construction of the sewer. Well-drained soils would probably carry away leakage, where underlying rock or tight clay would hold and pond it, submerging underground lines of any sort.

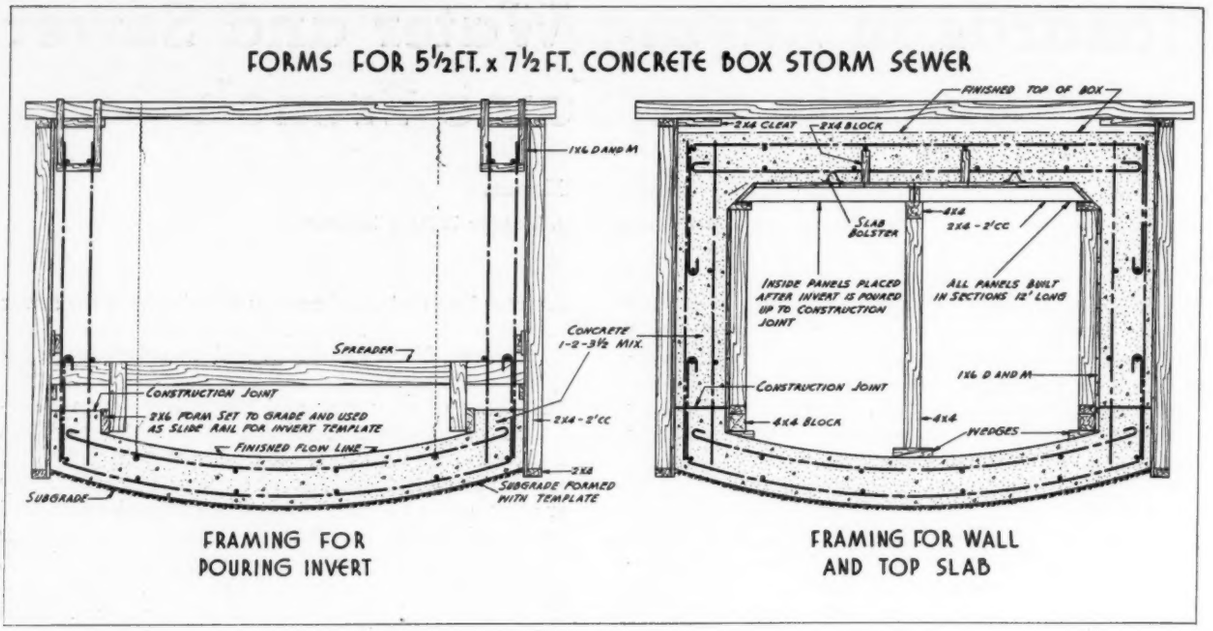
It goes without saying that, except where it is impossible to do otherwise, sewers should not be laid on a level above water pipes when they are in the same trench. Fortunately, the law of gravitation, if not other law, ordinarily causes the placing of sewers under the water lines, since basement drains to the sewer must ordinarily be from 6 to 8 feet below the street level, while water pipes are usually placed just low enough to prevent freezing.

It is the lateral brought from the houses at a higher level than the basement, paralleling the water service in the same trench and even crossing over the top of the water main in order to reach the street sewer, that may cause trouble. This may be corrected in future construction, and in repairs and relocations of old lines, by requiring such laterals to cross under water lines and to keep away from water service lines at a fixed minimum distance. This, of course, requires a city water and sewer map, with profiles.

The city of Lexington, Va., specifies that this distance shall be at least 3 feet, which is rather close, but the soil there is rather dense clay, relatively impervious when in its natural state or when backfilled carefully. The state of Minnesota requires 8 feet, and when it is necessary to bring the lines closer together, cast iron pipe with watertight joints must be used. Even this distance is too small when the soil is porous, of crevassed rock, or underlaid by impervious materials which may pond the leakage. Competent engineers have allowed installations of pipe in the same trench, but then the sewer was required to be not less than 5 feet below the water line, and the water line was laid on a shelf at the side of the trench.

Of course, the best insurance for a good water line is tight joints, a firm, non-settling bed, and a backfill of uniform and well-compacted soil, with the sewer line located as far as possible from it. In some cases sewers have been laid in alleys at the rear of the lots while the water lines run in the streets, or conversely. Even in such cases, precautions have to be observed when the lines cross.

This is an abstract of remarks by Capt. Hanes at the Virginia Water Works short school, held at Charlottesville, Va., May 12 and 13.



A Million-Dollar Storm Sewer Project by WPA

By RAYMOND A. ORPUT

City Engineer, Rockford, Ill.

ROCKFORD'S WPA storm sewer project is the largest single construction program ever attempted by this city; it is recognized as one of the most outstanding in the state of Illinois.

To tackle a million-dollar storm sewer construction program on WPA may be the height of intestinal fortude, but when one is confronted with a great public need and has no other way to finance such a program, intestinal fortude may be a virtue and not a vice.

Everyone who has ever had any experience with the WPA knows that estimates had to be brought down to a "gnat's eye" for reasonableness; and then when the job commences, one is sure to be forced to carry on the work under the most unfavorable circumstances, thus throwing all estimates to the winds and leaving you to save your own shirt, if you can, when facing actual conditions.

Mr. Orput

So with Rockford's great storm sewer program. To take what we could get in supervisory personnel; to expand our own personnel to keep a watchful eye on the project; to become suddenly a contracting agency as well as an engineering organization; to scrape up equipment from "God knows where" to help the workers; to give them a half-way equal chance against nature and the elements in sub-zero weather—these were some of the practical problems facing us in launching our program.

In Rockford, as elsewhere, the Lord made the drainage areas, and they were nicely divided over the city of some 90,000 souls. Thus in the problem of satisfying universal demands for WPA, benefits were automatically apportioned.

The storm sewer problem of Rockford was particularly urgent since in years past, when paving programs were under construction, short lines of storm sewer were constructed in conjunction with the paving. There was, of course, no great evil in this except that, due to a lack of outlets for these lines, they were connected with the sanitary sewer. As can be readily understood, with the greater and greater extension of this idea, as the city grew, the inhabitants found that instead of being troubled with surface water during storms, they were troubled with sewage backing up in their basements due to the overloading of the sanitary sewer mains.

Many of the storm sewer drainage areas were small and offered no particular problem in construction. However, there were two larger drainage areas, approximately a section square in size, that developed into major construction jobs. One of these areas, known locally as the South-East End District WPA Project 2970, drained into an outlet known as WPA Project 2969.

The excavation for this trunk line outlet sewer amounted to some 35,000 cubic yards of earth. The construction was a monolithic concrete box conduit 7½ feet by 5½ feet with approximately 600,000 pounds of reinforcing steel. Some 1,300 feet of this outlet was of open ditch construction on a 1 to 1 slope with banks and floor laid up of quarried stone taken from the city quarry by WPA labor.

The monolithic box required special design treatment since 1,200 feet of it paralleled a railroad switch line and had to be designed so as to provide for additional switch lines to be run across the conduit in the

future at any point desired. This conduit was designed as a monolithic box with stiff corners. It was reinforced on both faces of all slabs to take care of any eventual loads.

Power Equipment Needed

It was learned soon after the starting of construction of this project that even in the face of unlimited man power certain equipment was absolutely indispensable. Accordingly we placed one ¾-yard Northwest clam and crane on the job in the very early stages of construction. On the entire drainage district, i.e., the South-East End District and its outlet, we find it necessary, now that favorable weather conditions have arrived, to place three gas shovels on the job varying from ½-yard to 1-yard in size.

It has been remarkable to see the results that can be obtained from relief labor. Great inefficiencies naturally resulted in the early formative organization stages; and the unfavorable weather conditions at that time accentuated these. However, as favorable construction weather arrives and crews become well organized, a real record of accomplishment will be made, I have no doubt.

The forming problem on the concrete conduit presented an interesting problem; also the proper placing of reinforcing steel. The accompanying sketches illustrate how this work was performed. The accompanying photograph shows the curved conduit entering the junction chamber leading to the outlet trunk line for the storm sewer system.

Above, reinforcement in place; below, a curve at the junction of two sewers.

Cost Data and Records

The city's share of the cost of this construction ($1,000,000) will run from $100,000 to $150,000, which is paid for from its share of the state motor fuel tax funds. Because of the interlocking financial responsibility of the city to both the National and State governments, it was necessary to maintain a system of records which provided the administrative branches of city government with accurate periodical summaries, showing the relationship of city contributions as compared with the original WPA project applications requirements. Also it was necessary to provide progress reports showing actual costs as compared with estimated costs. This report sheet, a copy of which is shown herewith has proved a great aid to the city administration in keeping close contact with the job in order to diagnose the physical and financial problems arising long before they become acute. These records have proved so valuable that WPA administrative units have asked for these forms for maintaining their own records of job progress.

I am led to conclude from my own experience that the practical use of relief labor is one based solely upon the fertility of the mind of the individual administrator in a community. Rockford is now using 2,000 men on WPA work, constructing street pavements, paving alleys, building beautiful stone retaining walls on creeks, repairing sidewalks, augmenting its street maintenance work and eliminating dead-end mains on its water systems. All of these projects are practical and are accomplished without one cent of additional taxation.

Summary of Cost Data Progress Sheet

	FEDERAL FUNDS	%	SPONSOR'S CONTRIBUTION	%	TOTALS	%
Labor	113,100.00	99.3	825.00	.7	113,925.00	100
Mat'l. & Sup.	47,956.87	71.8	18,830.06	28.2	66,786.93	100
Equipment			4,212.00	100.	4,212.00	100
Other Direct Cost	866.80	10.4	7,451.00	89.6	8,317.80	100
Totals	161,923.67	83.8	31,318.06	16.2	193,241.73	100

SUMMARY OF EXPENSE TO DATE

	FEDERAL FUNDS	%	SPONSOR'S CONTRIBUTION	%	TOTALS	%
Labor	56,453.44	97.7	1,327.52	2.3	57,780.96	100
Mat'l. & Sup.	30,627.82	79.5	7,889.95	20.5	38,517.77	100
Equipment			4,564.76	100.	4,564.76	100
Other Direct Cost			4,449.67	100.	4,449.67	100
Totals	87,081.26	82.7	18,231.90	17.3	105,313.16	100

UNIT COST

		Proposal	Finished	Balance	Estimate	Actual
12" Pipe	Lin. Ft.	14,526	5,798	8,728	1.73	2.64
15" "	" "	3,080	444	2,636	2.12	2.52
18" "	" "	4,171	1,830	2,341	2.55	5.22
21" "	" "	3,408	1,725	1,683	3.21	6.17
24" "	" "	2,712	804	1,908	4.37	10.02
27" "	" "	2,811	1,086	1,725	5.01	10.94
36" "	" "	1,355	478	777	7.06	10.47
48" "	" "	2,576	930	1,646	10.11	13.02
Manholes & Catch Basins	Each	134	62	72	60.00	47.94
Curb Inlets	"	124	34	90	25.00	34.55
Sheathing	Lin. Ft.	10,000	1,860	8,140	1.00	1.27

The cost records devised for this job excited much favorable comment. A portion of one sheet is reproduced here.

Tennis courts constructed on top of a storm sewer

Improving Open Stream Conditions in Atchison

By A. W. SENG
City Manager, Atchison, Kansas

OPEN creeks and small streams running through a city are always a source of annoyance to those responsible for the administration of the city's affairs, and to the people who reside or have their places of business adjacent to them. In spite of everything that can be done to prevent it, there is always a certain class of people, especially those who eke out a precarious living collecting rubbish, garbage, etc., who will surreptitiously dump their collectings on the banks of such streams instead of taking them to the places provided by the city. This is especially so in cities which have no garbage collecting systems or incinerators, and even in those cases it seems that old tin cans and other rubbish naturally accumulate on the banks and in these streams and it is always difficult if not impossible to stop this. "NO DUMPING" signs have but little effect because the modern American does not believe in signs any more. One darky, who was caught dumping in a prohibited area plainly marked by signs, when brought before the Police Judge protested his innocence by saying that he did not dump near the sign but was at least twenty feet away from it. More often than not such places are the harbors of rats and other vermin.

In the City of Atchison, Kansas, is a creek which runs almost through the center of the city from west to east and empties into the Missouri river at the east edge of the city. It has one principal branch coming down from the north which divides the north half of the city into almost equal quarters. This branch again subdivides at about three thousand feet from its mouth, one fork running off to the northwest and the other to the northeast. All have running water in them, although it gets very low (about 200 gpm. in the branch and 500 gpm. in the main creek) during dry weather. The main creek runs almost entirely through the business and industrial part of the city and the branch almost altogether through the residential section. Both were everything described above and more, as the pictures show.

In the year 1920 the governing body of the city decided, as a sanitary measure and to eliminate an eyesore, to enclose the creek with a reinforced concrete box sewer. The plans and specifications were provided by Black & Veatch, consulting engineers, of Kansas City, and called for two parallel boxes, each 12 x 13 feet with steel reinforced walls 12 inches thick and extending back from the river 3,000 feet, the total cost of which was estimated to be $445,000. The first section, 2,200 feet, of this was built in 1920 and '21, and the next 800 feet was added in 1926-27.

In 1932, as a relief labor project, a 7½ x 7½ concrete box was started in the branch of the creek, ex-

Box storm sewer at Atchison

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tending 1,400 feet from the junction with the main creek. This was a force-account job and the cost of the common labor was paid out of funds furnished by the FERA, the city furnishing all skilled labor and material.

Another section of 1,600 feet was added to this in 1935, under the PWA with a 45% grant, the city issuing bonds for the remaining 55% which took a rate of 2 and 2¼% and were sold at a small premium. This section was built by contract with labor furnished by the local relief organization. The quality of the labor was very good and there was very little turnover in the personnel. This latter section extended beyond the fork of the branch and was continued with a 5 x 6 box in the northwest fork and a 6 x 6 box in the northeast fork. The thickness of the walls in the branch sewer was 8″.

White Clay creek before improvement.

Nearly all this construction was done in the winter time in order to take up the slack in the labor situation and relieve unemployment. High-early-strength cement was used almost altogether in the branch sewer. The difference in cost of this cement was easily compensated for by the time saved and gained in moving forms, as they could be removed and reset in 12 to 14 hours. The invert or floor was laid considerably in advance of the sides and top, the running water being diverted through a side ditch or pumped with a small gasoline pumping unit into the finished sewer.

All the mineral aggregates and mixing water were heated and in real cold weather a large kerosene torch was used to heat the inside of the concrete mixer, which of course speeded up the setting of the concrete; in addition, the concrete after pouring was kept from freezing by two or three salamanders or stoves placed inside the newly poured section, the ends of the sewer being closed up with canvas.

It is expected that in the near future sewers will be continued for another 1,000 feet in each fork of the branch. The value of such an improvement can hardly be estimated or the improvement realized until the work has been completed, depressions filled and surface improvements made and then compared with the original ditch. Some very sightly and useful improvements have been made in Atchison on the space formerly serving as dumps and rat harbors. Some of it has been parked; a vegetable market occupies a space 150 x 180 feet; a number of filling stations have been erected; two automobile parking yards have been established, one 150 x 135 and the other 150 x 225 feet; a band stand covers one space, and another contains four tennis courts and an archery range.

Estimate 37,100,000 Cars and Trucks on Highways by 1960

The year 1960 will find about 43 per cent more motor vehicles traveling the roads of the United States, it is estimated by the American Petroleum Institute. A recent survey by Institute committees developed expectations that the 22,400,000 passenger vehicles registered in 1935 would increase about 39 per cent in number to 31,100,000. It was estimated that the 3,600,000 motor trucks would increase in number to 6,000,000. Total registration for 1960 was estimated at 37,100,000 as compared with 26,000,000 for 1935.

Fuel consumption per car is seen as increasing from the average of 690 gallons per vehicle per year in 1935 to a peak of 730 gallons in 1940, and then declining to 670 gallons in 1960. While it is believed that the number of miles traveled by each car per year will continue to increase, it was predicted that there would be a decided trend toward cheaper and lighter vehicles consuming less fuel. There were indications of an increase in the use of diesel fuels for heavy vehicles.

Following are estimates by five-year periods:

Year	*Passenger Cars*	*Motor Trucks*	*Total Registration*
1935	22,400,000	3,600,000	26,000,000
1940	24,900,000	4,300,000	29,200,000
1945	26,700,000	4,800,000	31,500,000
1950	28,600,000	5,300,000	33,900,000
1955	29,800,000	5,650,000	35,450,000
1960	31,100,000	6,000,000	37,100,000

Operating Data of a Sewage Treatment Plant

The following is a brief list of the operating data which are recorded at the Palo Alto sewage treatment plant: Daily—Volumes of sewage flow; screenings removed; raw sludge pumped from clarifier to digester; average percent moisture and average volatile matter of raw sludge; power used, total and for lights; power generated; volume of fresh water used; volumes of gas used by gas engine, for heating, and burned in waste burner; number of hours gas engine ran and amount of lubricating oil used. Two or three times a week—pH of digester overflow liquor, of raw sewage and of raw sludge; temperature of digesting sludge, of raw sewage and of raw sludge. Also, when digested sludge is drawn, composite sample is taken and percent moisture determined and volatile content of dry solids. Twice a week, samples of raw sewage and effluent taken at 2-hr. periods for 23 hr. are composited and suspended solids and 5-day B.O.D. determined; also, 2 hr. settleable solids tests are run on catch samples of raw sewage and of effluent, which are taken at 11 a. m. and 1 p. m. respectively. Whenever sludge is drawn from the clarifier, a sample is taken, and these are composited over a 24 hr. period and the composite sample tested.

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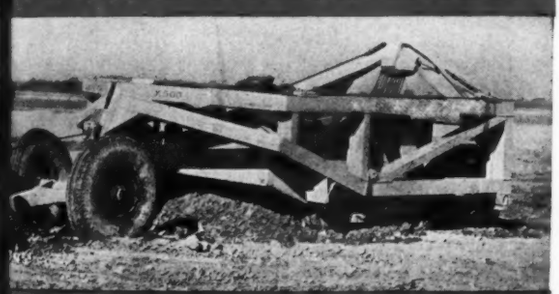

Digging: Front and rear of pan are in the same plane for loading. No power loss from loading at an incline.

Dumping: Factory view shows dumping clearance. Forward dumping and spreading permits scrapers to operate in tandem.

● The low price alone of the new Austin-Western 5-Yard Scraper is plenty of reason for this special announcement—for your special attention—special action, now, to take advantage of it this year. But this point is overshadowed by actual improvements—new features! New performance! Here are some highlights:

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When digging, the pan is level with the ground so that the dirt moves directly back into the pan instead of up an incline. The wheels travel inside the six-foot cutting width to make this possible.

The scraper cuts to a depth of 6 inches and spreads the load to any depth up to 9 inches. Forward dump makes the spreading action possible while the machine is traveling in high gear.

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Following is a digest of the important articles published last month having to do with water works design, construction and operation and water purification, arranged in easy reference form.

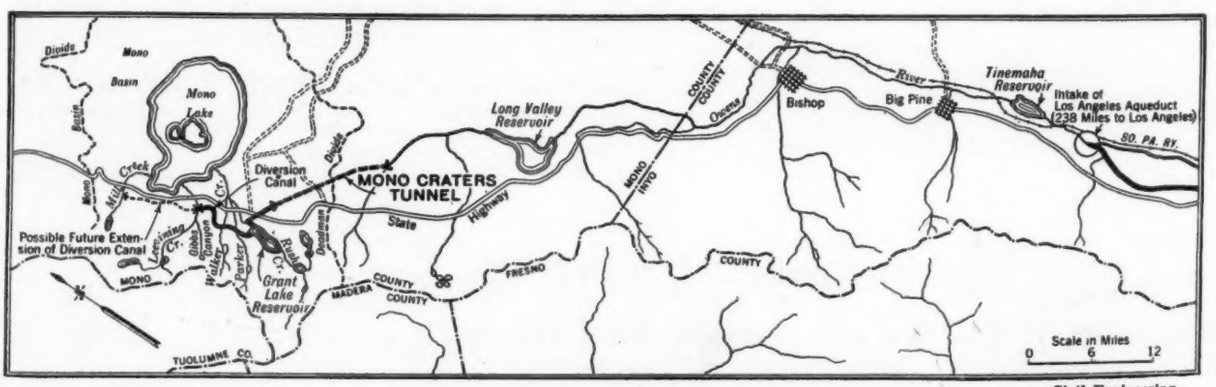
The Water Wheel

Odors in water can, by improved methods of testing, be detected in intensities less than can be detected by users of the water. The general method is employed of diluting with odor-free water until odor is just detectable, but the 500cc flask is filled just half full of water, giving equal volumes of water and air in flask; the air dilution method is not accurate enough. For hot odor tests, the flask is heated to 70° C by immersion for several minutes in water of 80°, with no agitation until the desired temperature is reached, and then thorough agitation and prompt testing. Repeated agitation and testing will generally give progressively decreasing odors. Metal flask covers affect odors, especially in the hot test, and glass apparently is necessary, but loosely fitting covers (watch glasses) allow some of the odor to escape. Using the improved and exact methods, skilled laboratory workers can detect odor threshold differences of 20% or less. "The pO scale of recording odor tests suggested by Fair is not the most convenient form of expressing the results. It . . . cannot be used for computing dosages of powdered activated carbon," as can the threshold number. "The osmoscope as now manufactured gives dilutions which vary too widely for close results." "The efficiency of various treatments for removing a particular odor may be compared fairly accurately by determining the odor threshold numbers of the water before and after treatment."[A29]

Katadynization of water was investigated in the Warsaw (Poland) State School of Hygiene, and the following conclusions reached: The action of the silver is independent of the way in which it is introduced into the water. A large part of it remains ionized for weeks or months and therefore there is no aftergrowth of spore-forming bacteria or secondary contamination. Several dozen rats fed with water containing 4 to 10 times the dose proposed for drinking water during 100 days showed no obvious symptoms of poisoning, but their livers, kidneys and spleens showed pathological changes. "Constant use of water disinfected by means of silver cannot as yet be considered quite innocuous to health" but probably "temporary or occasional use of water disinfected by means of silver, as during scientific expeditions, excursions or during war time will not produce symptoms of poisoning." Use of silver for algae control or disinfection of swimming pools may be recommended owing to its effectiveness and absence of taste and odor, but is much more expensive than chlorination. The size of dose required cannot be based on calculations exclusively, but should be controlled by means of chemical analysis.[A28]

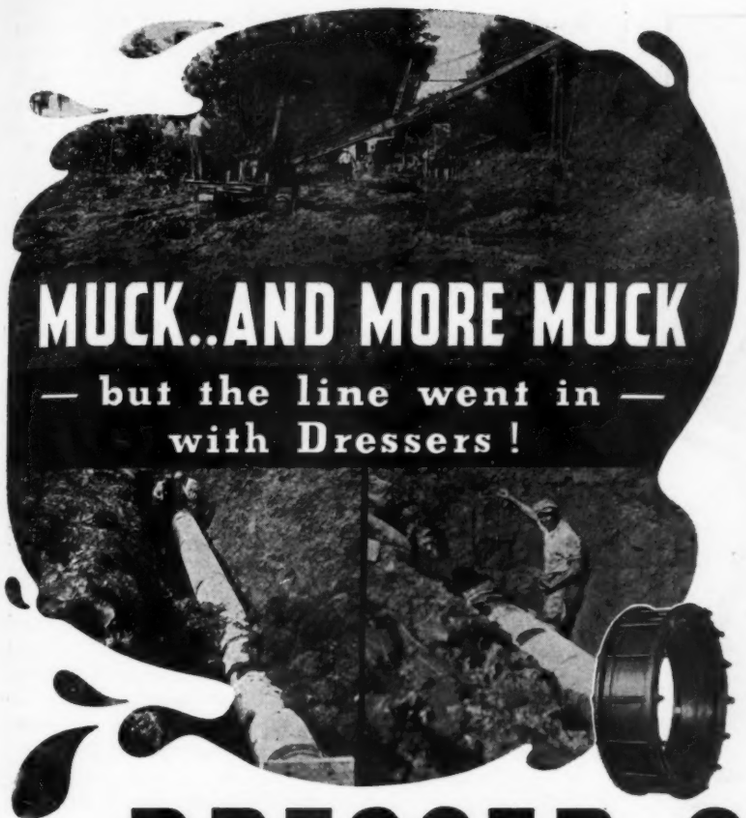
Chloramines are applied to Asheville, N. C., water in the two 16 in. mains which carry it from the intakes to the balancing reservoirs. B. Coli had been found in city tap water at intervals during every summer for years, probably from contamination in the open reservoirs. Beginning Dec. 1934 two visible vacuum automatic chlorinators, two automatic ammoniators, and one visible vacuum manual chlorinator for a standby, went into service. Ammonia is applied 30 ft. ahead of the chlorine and mixed through venturi tubes. As the pH of the water is usually about 6.8 there is relatively quick formation of monochloramine and dichloramine. The water is distributed to 86,000 people through 352 miles of pipe. Using an average of 0.4 ppm of chlorine and 0.1 ppm of ammonia, residuals in the reservoir ranged from 0.05 to 0.18 ppm, and no gas formers were found in any tap water taken 16 miles from the sterilization plants. Chlorine was carried into mains which it had never reached under the previous plain chlorination and old deposits here were abruptly oxidized and produced tastes and complaints, which ceased within a week or 10 days. It is believed that less chlorinous taste will result when commencing use of chloramines in an old system, especially where the water has not been filtered, if the ammonia dose be started very low and gradually advanced by easy stages to the desired point.[F21]

The **Mono Basin** extension of the Los Angeles aqueduct is being built beyond the headwater of the Owens river to add 195 cfs to that city's supply. It will cost about $11,000,000 and is scheduled for completion in 1938. The project includes a diversion canal intercepting three streams, a reservoir on a fourth stream of 48,000 acre-ft. capacity, a gravity line (pipe line and tunnels) to the head of Owens river; and a reservoir



Civil Engineering.

Mono Basin Extension of Los Angeles Aqueduct



No one would deliberately pick a swampy right-of-way for a pipe line. Yet that was the unavoidable condition encountered on the 19-mile water-supply line from Lake Canandaigua to Palmyra, N. Y. And, so, straight through the muck and marshes the workmen went—simply *assembling* (NOT fabricating) the joints in watery ditches . . . and making a bottle-tight job of it, too! ● That's one of the great advantages of using Dresser Couplings —you don't need to worry about the kind of terrain or weather. ● A mile of this Palmyra line extends into the lake. Full details of the special Dresser Couplings used on this intake section are available on request. Also ask for folder No. 355, which gives you the story of Dresser permanent tightness, flexibility, simplicity, strength, and *true* economy.

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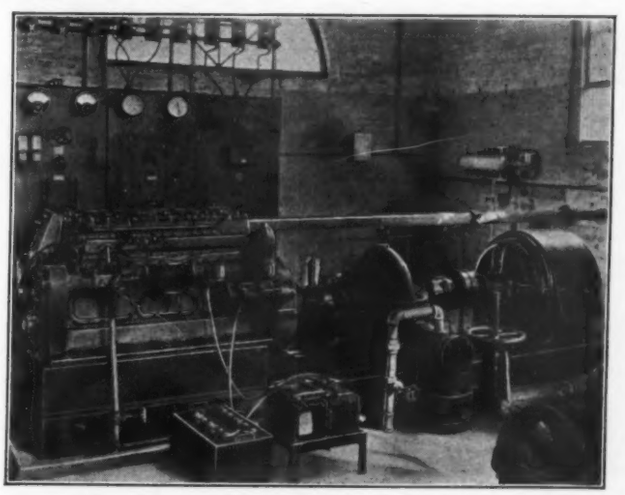

For standby in emergency, the Gulf States Utilities Company, Lake Charles, La., employs a Sterling Petrel 6 cylinder 170 H.P. engine to drive a Worthington centrifugal pump at 1750 R.P.M.

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lower down on that river. The aqueduct will have a capacity of 300 cfs at the upper end, increasing to 420 cfs at the lower end. One tunnel (Mono Craters) will be 11.3 miles long, 9 ft. in diameter, built from six headings, two from a shaft 950 ft. deep and two from one 350 ft. Drilling began in the fall of 1934 and by April 1, 1936, 12,507 ft. of tunnel had been drilled from the west portal, 9,095 from the east portal, and 3,815 ft. from the shorter shaft. It is believed that the world's record for hard rock tunnelling was broken here—a progress of 90 ft. at one heading in 24 hrs. This tunnel is estimated to cost $7,200,000. The flow through it will discharge into Owens river and flow 30 miles into a reservoir of 163,000 acre-ft. capacity, made by a rock-fill dam faced on both sides with arc-welded steel. Work is being conducted on the tunnel in three 8-hour shifts 6 days a week, using specially designed machinery.[L1]

A movable pumping plant was built last year for Uniontown, Ky. At present the city is on the Ohio river, but the river has moved 1,200 ft. since 1900 and may continue to move, and for a small city it is easier to move the plant than the river. Hence a 250 gpm centrifugal pump, with its primer, is mounted in an insulated weather-proof house on wheels which run on a track laid down the river bank. Power for the motor is supplied through a cable, the control switch being located at the filter plant. A suction hose connects with an intake under normal water level, and a second intake is provided for use when high water necessitates hauling the pumping plant up onto higher ground. The discharge from the pump is connected to the nearest of four uprights from a pipe line laid adjacent to the inclined track. A small oil stove in the pump house is provided against extreme cold weather.

The filter building, to provide against high water, has no window or other opening below a level about 10 ft. above the ground, except the entrance door, and this is provided with an aluminum bulkhead door which can be handled by two men and fastened to the door casing, making this opening also watertight.[F18]

Priming of boiler water (carry-over of liquid water in the steam) is increased by presence in the water of certain kinds or forms of solid matter, is not affected by others, and is even decreased by some. Some kinds that cause priming when first introduced into the boiler or when first precipitated inside the boiler, lose that property after sufficient time of contact with hot boiler water; the rate of such loss increasing with the temperature, at least for introduced solids. Priming in general is greater at low than at high pressure.[A50]

A **meter testing and repair** program, definite, efficient and consistent, is a vast and lasting asset to any water utility, irrespective of size. It includes exchanging, testing and repairing meters and keeping records of all these operations. In Louisville, which has 50,000 meters in use, one man with helper exchanges 35 meters a day; 10,000 are removed a year, tested, cleaned, repaired if necessary, tested (a ⅝ in. meter at 10 gpm, 1 gpm and 0.25 gpm). Ten meters tested at a time, using calibrated tanks (not weighing). All new meters have sweep-hand dials, which facilitate testing and detecting leaks. Meter tester and helper test over 100 ⅝-in. meters a day; first tests of meters as received in the afternoon, final tests in the morning. Five repair men average 15 to 20 meters a day each. No machining or reboring is done—replacement is cheaper and safer. 50 new discs a month are used. Bottom bolts and gaskets are the parts most often needing replacement.

The A.W.W.A. specifications for ⅝-in. meters are

too lenient—a well-constructed meter should register much closer than 90% on 0.25 gpm. At one time 300 meters 5 years or more in service registered much better than this as received after removal. "As meters go, so goes your revenue."[G11]

Electric grounding of wires on water pipes involves some dangers where direct current is used, but only slight ones with A.C., the electrolytic action of which is only one or 2% that of D.C. "There should be a definite rule that no direct current wires are to be grounded to the water pipes." D.C. is ordinarily used only by certain industries, such as electroplating factories, piping systems of which have failed completely from this source of trouble. Lead pipes are especially subject to such deterioration. Radio grounding might constitute a fire hazard if a poor connection were made near a leaking gas meter. The standard telephone wire in a residence is free from hazards. With Neon signs the voltage is stepped up to 15,000 volts and the grounding of the transformer shell to a water pipe would create a serious hazard. However, the records do not prove that serious hazards from any of these causes have actually existed.[A24]

Bibliography of Recent Water Works Literature

c, Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

A *Journal American Water Works Ass'n*
April

23. Plankton Control in Morris Reservoir. By C. W. Sopp, pp. 447-457.
24. Hazards in Use of Public Water Supply Systems as a Ground for Electrical Circuits. By D. W. Johnson, pp. 458-468.
25. Economics of Water Softening. By C. M. Stanley, pp. 469-478.
26. North Carolina Rainfall By L. A. Denson, pp. 479-483.
27. Geology of the Coastal Plain of North Carolina. By W. F. Prouty, pp. 484-491.
28. Germicidal Properties of Silver in Water. By J. Just and A. Szniolis, pp. 492-506.
29. An Improved Odor Test on Water. By J. R. Baylis and O. Gullans, pp. 507-527.
30. Suspended Solids in the Foaming and Priming of Boiler Water. By C. W. Foulk, pp. 528-535.
31. Purification Methods at New Orleans. By C. C. Friedrichs, pp. 537-541.

E *Engineering News-Record*
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8. *c*. Novel High-Pressure Grouting Methods Seal Fissures in Wet Tunnel. By C. R. Rankin, pp. 661-663.
9. Watering the Great Plains. By G. S. Knapp, pp. 664-665.

F *Water Works Engineering*
April 29

18. Flood-Proof Plant Has Many Novel Features. By E. C. Handorf, pp. 482-485.
19. Mineral Springs, Mo., to Operate Mineral Water Resort. By B. S. Almott, pp. 486-487.
20. Laboratory Control: Determination of Alkalinity. By C. R. Cox, pp. 488-490.

May 13

21. Chloramines Simplify Sterilization of Asheville Water. By W. J. Parks, Jr., pp. 536-539.
22. *p*. Keeping Water Meters Fit. By C. A. Gallagher, pp. 540-543.
23. Laboratory Control: Determination of Alkalinity. By C. R. Cox, pp. 544-545.

G *Water Works and Sewerage*
April

11. *p*. Meter Testing and Repair. By C. A. Gallagher, pp. 107-111.

J *American City*
May

5. *n*. New Deferrization Plant at Reading, Mass. By P. Welch, pp. 72-73.
6. *n*. Fast Billing at Brainard, Minn. By W. D. McKay, p. 77

L *Civil Engineering*
May

1. The Mono Basin Project. By H. A. Van Norman, pp. 306-308.

M *Canadian Engineer*
April 28

19. Laying Reinforced Concrete Pipe Lines at Regina, Sask. By J. W. D. Farrell, pp. 16-17.

May 12

20. Rational Design of Swimming Pools. By E. H. Darling, pp. 3-8, 12.

P *Public Works*
May

9. *c*. Vibration Construction of Filtration Plant, p. 15.
10. Equipment Used in Water Purification, pp. 20-22.
11. Water Supply for Summer Camps, pp. 40, 42-43.
12. How 2-Inch Cast Iron Pipe Is Made. By A. K. Akers, pp. 53-55.
13. *n*. Activated Carbon in Water Treatment, p. 55.

Q *U. S. Piper*
June

2. Flexible-Joint Cement-Lined Cast-Iron Pipe at Coney Island, pp. 24-25.

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Damp-Proofing Pumping Station Walls in Baltimore

THE city of Baltimore is now completing work on the construction of the Ashburton pumping station, an important new unit in its water supply system, designed to serve a large area comprising about 35 square miles in the city and suburbs, known as the western high service territory. The project was commenced in 1934 and involves a total cost, with building equipment, and appurtenances, of approximately $400,000.

The building is approximately 100x71 ft., a cut stone superstructure on concrete foundations. The pump pits contain, in a compact layout, two 18 mgd two-stage centrifugal pumps with 900 hp motors, and two 12 mgd two-stage centrifugals with 600 hp motors. The present average load is 12 mgd with summer peaks reaching about 20 mgd.

The bottom of the pump pit is approximately 20 ft. below the ground surface and the ground water level, though fluctuating considerably, rises intermittently nearly to the surface. As it is essential that the pump pits be perfectly dry at all times, the necessity for the most exacting and dependable type of damp-proofing of walls was apparent.

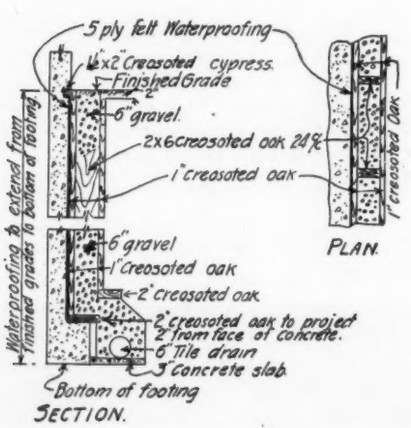
In securing the desired water-tightness, the outer surfaces of the exterior walls, entirely around the building, were waterproofed with a 5-ply membrane water-proofing, the first three layers being of asbestos felt, and the final two of a lighter canvas or cotton duck, all layers preceded and followed by a thorough swabbing of hot pitch. The several layers were placed in vertical strips, carefully shingled to afford full and accurate coverage, and a heavy final coat of hot pitch applied.

At the ground surface, surrounding the whole area, a 1½x2-in. pressure-creosoted strip of clear cypress is embedded in the masonry walls, its face flush with the outer surface. It is anchored with copper nails driven into the rear corners, the heads of the nails extending into the concrete. On the top surface of this strip a sheet of copper flashing is nailed, with copper nails, the flashing extending out so as to be bent down over the membrane water-proofing previously described.

Pressure-creosoted 1x6-in. oak boards, tightly nailed up to 2x6-in. studs, forming wall plates, were then placed in contact, the plate side to the water-proofing membrane. Specifications very carefully called for no protruding nails or nail heads in contact with the membrane. On the assembled wall plates a second sheathing, similar to the first, is nailed, leaving, it will be observed, a 6-in. space between the two lines of sheathing. On a 3-in. concrete slab at the bottom, opposite the wall footings, is laid a 6-in. tile drain, after which the space provided by the 6-in. studs is filled with clean coarse gravel, graded to approximately equal size to provide maximum voids.

After the double wall of sheathing is in place, and the gravel fill under way, earth is backfilled against the sheathing in shallow layers and carefully puddled to secure the best possible compactness. The 6-in. tile drain, laid with open joints but wrapped with burlap, leads to a sump in the building, where the discharge of water is drained into the sewer and there disposed of. After an unusually wet season, it is gratifying that the walls and floor of the machinery pits have remained in a perfectly dry condition.

As will be appreciated from the detail of the plan shown here, ground water is intercepted by the vertical



Left, method of construction; right, construction views.

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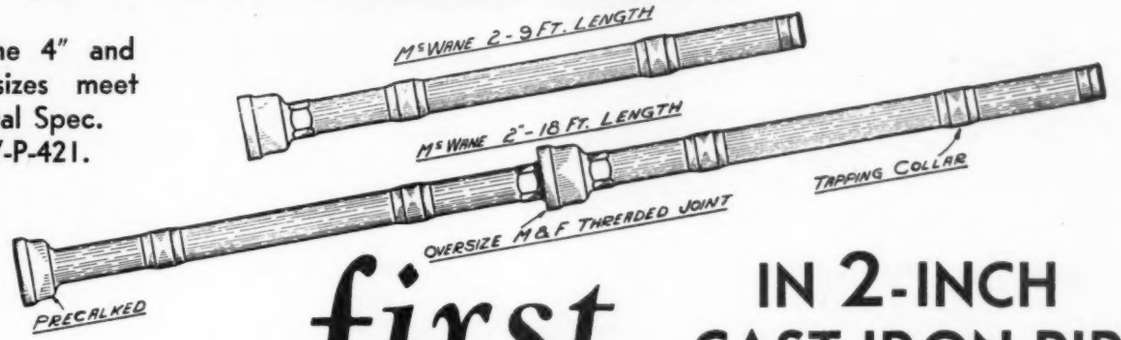

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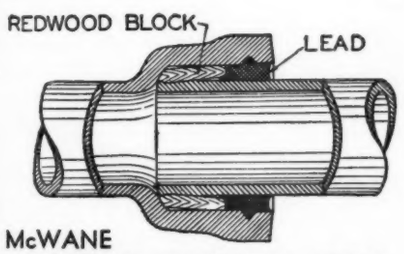

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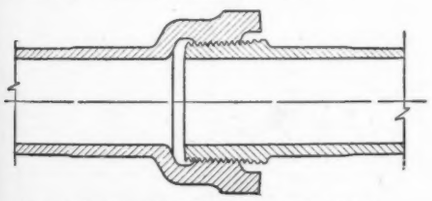

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layer of coarse gravel contained within the creosoted wood sheathings and flows down into the drain, thus relieving the membrane of all except residual moisture. The wood surface acts as a protective member to the membrane, preventing any abrasion from the gravel, and as the backfill forms a relatively tight mass, the water passing through it has high frictional resistance and drops quickly as it reaches the porous gravel wall.

The same or similar schemes have been utilized in other pumping stations in Baltimore, but untreated wood was used, and it was found in the course of a few years that the wood had decayed and thus threatened the integrity of the water-proofing membrane. In this case, where pressure creosoted wood is employed, and with the knowledge that when such material is not exposed to the action of the elements it will remain permanently sound, there is every reason to believe that the procedure will afford perfect and permanent protection from infiltration of ground water into this building.

A total of approximately 12,000 bd. ft. of creosoted sound and square edge mixed oak lumber was required for sheathing and studding in this construction. After seasoning by the Boulton process the lumber was treated with a final retention of 10 lbs. grade one coal-tar creosote per cubic foot of wood by an empty-cell process.

The building was constructed for the city of Baltimore by the Consolidated Engineering Company as contractors. John H. Gregory is consulting engineer; Frank O. Heyder, architect; Bernard L. Crozier, chief engineer; and Leon Small, under whose direction the design was prepared and the work done, water engineer of the Bureau of Water Supply.

For the above information and illustrations we are indebted to "Wood Preserving News."

Operation of Dayton Sewage Screenings Incinerator

By M. W. TATLOCK
Superintendent of Sewage Treatment

THE incinerator which forms a part of the sewage treatment works of Dayton, Ohio, was designed to burn the screenings from the Dorr screens and from the 4-inch bar racks in the sewage pumping station, as well as the grease skimmings from the detritus tanks. It is gas fired, using gas collected from the Imhoff tanks. It vents through a 20 feet long breaching into a stack 60 feet high.

Ample safety provisions have been made in the installation to prevent backfiring through the gas line and to shut off the gas supply in case of fire. There is a shut-off valve outside the building as well as inside. The gas pressure regulator on the line has a cut-off feature which automatically closes and locks the valve if the pressure in the diaphragm case falls below the operating pressure. This feature makes it impossible to again light the pilot light until the operator has set the latch by hand. A water seal on the line to the burner prevents backfiring through the line. An orifice meter provides a record of the pressure and rate of consumption of the gas. A pyrometer and automatic temperature control valve gives a continuous record of the temperature, at a point for which the control indicator may be set, by opening and closing a valve in the gas supply line to the burner.

The burner is water cooled with an operating range from 3 pounds to 20 pounds. Its rated capacity is 1600 cubic feet per hour at five pounds pressure, with a burner tip of .25-inch ID orifice. The orifice now in use is 13/16-inch ID and is operated at a pressure which varies from 12 to 20 pounds.

The charging chute empties into a storage hopper, directly over the fire box, which holds approximately one day's screenings. The screenings are discharged from this hopper onto a hearth 6 feet wide, which slopes about 5° to the grates, which are 4 feet wide. Stoking doors are provided at the end and side of the hearth and grates, through which a poker may be used to stir up the screenings and thus aid combustion. Air for combustion is admitted through the ash door and through other doors along the side of the breaching, and a damper in the breaching also aids in the draught control. Holes have been left in the dampers to provide free air circulation and eliminate the formation of dangerous gas pockets when the incinerator is idle.

The screenings from the racks are hauled from the pumping station in cans. Those from the screens are accumulated in storage hoppers, from which they are dumped directly into the curbs of the hydraulic press. After a curb has been filled it is subjected to a pressure which reduces the volume to approximately 50% of the volume before pressing and the moisture content to 69%. One cake from each day's screenings is weighed and the height of each one is measured; then the weight per cubic foot of the weighed cake is applied to all the others on that day to determine the weight burned. A sample of each pressed cake is taken and sent to the laboratory where they are composited and the moisture determined. The pressed cakes are broken up on the floor and fed through the charging chute into the storage hopper where they dry out considerably from the heat left from the previous day's burning. The pressing and burning is done at night. The ashes are used for filling low ground. No odor nuisance is noticed if the fire-box temperature is maintained near 1800° F.

The following table gives a summary of the screenings handled from the sewage during the year 1935:

Table I—Material Handled, 1935

					Screenings Collected	
	M.G.	Pressed Cakes		%	Cu. Ft.	Lbs.
Period	Treated	Cu. Ft.	Th. Lbs.	Moisture	per M.G.	per M.G.
1	589	963	55.7	66.2	1.64	95
2	557	1094	63.3	63.9	1.96	114
3	616	1305	75.5	67.4	2.11	123
4	646	1430	82.7	68.8	2.21	128
5	798	996	57.6	68.8	1.25	72
6	645	1089	63.0	68.9	1.69	98
7	645	1119	64.8	68.0	1.73	100
8	651	896	51.8	70.0	1.38	80
9	642	971	56.2	74.4	1.51	87
10	572	1084	62.7	68.7	1.89	110
11	547	923	55.3	69.0	1.69	98
12	603	906	52.3	74.0	1.50	87
13	660	908	52.5	69.0	1.38	80
Total..	8171	13,684	791.4			
Average	628	1,053	60.9	69.0	1.69	98

Table II gives the quantity of screenings burned, the hours of incinerator operation, the gas required and the

Table II—Fuel Required

		Incineration Screenings			Gas Used			
	M.G.			Lbs.	Thousand Cubic Ft.		Cu. ft.	Cost
Period	Treated	Th. Lbs.	Hrs.	per Hr.	Total	per hr.	per lb.	M.G.
1	589	55.7	107	521	113	1.056	2.03	.075
2	335	48.6	102*	476	123	1.206	2.53	.085
3	393	53.5	58†	922	100	1.724	1.87	.063
4	646	82.7	127	651	219	1.725	2.65	.132
5	798	56.6	92	626	171	1.858	2.97	.083
6	645	63.0	110	573	253	2.300	4.02	.152
7	645	64.8	129	502	277	2.147	4.27	.166
8	651	51.8	104	498	231	2.221	4.46	.138
9	579	50.6	94‡	438	224	2.383	4.43	.136
10	572	62.7	107	586	265	2.477	4.23	.180
11	547	53.3	96	555	211	2.198	3.96	.50
12	603	52.3	99	528	203	2.051	3.88	.131
13	660	52.5	101	520	232	2.297	4.42	.136
Total.....	7663	749.1	1326	7496	2622			
Average	589	57.6	102	577	202	1.973	3.52	.125

Note: Orifice 13/16". Pressure 12-20 lbs. *Represents 22 days' operation. †Represents 17 days' operation. ‡Represents 25 days' operation.

cost of this gas. In figuring the cost of this gas, it is calculated at the same cost per B.T.U. fuel value as natural gas which can be purchased from the local utility at a base rate of 55 cents per 1000 cu. ft. for gas rated at 1100 B.T.U. Since the Imhoff gas has a B.T.U. value of 775 it is worth 38.8 cents per 1000 cu. ft. The variation between the quantities shown in this table and table *I* are caused by the incinerator being out of service for repairs a number of days in the second, third and ninth periods.

Table III gives the total operating cost. The fuel costs are carried forward from table II. The labor charges cover the cost of pressing the screenings as well as the incinerator operation. This expense is for two men employed at 48 cents per hour. The repair cost includes both labor and materials for repairs to the interior brick work, dampers, grates and burner tunnel. Both the labor and repair charges have been equally distributed into each of the thirteen 28-day periods.

Table III—Cost Data

Period	*Fuel*	*Labor*	*Repairs*	*Total*	*Per M.G.*
1	$43.84	$166.88	$8.81	$219.53	$ .37
2	47.72	166.88	8.81	223.41	.66
3	38.80	166.88	8.81	214.49	.55
4	84.97	166.88	8.81	260.66	.40
5	66.35	166.88	8.81	242.04	.30
6	98.16	166.88	8.81	273.85	.42
7	107.48	166.88	8.81	283.17	.44
8	89.63	166.88	8.81	265.32	.41
9	86.91	166.88	8.81	262.60	.45
10	102.82	166.88	8.81	278.51	.49
11	81.87	166.88	8.81	257.56	.47
12	78.76	166.88	8.81	254.45	.42
13	90.02	166.89	8.81	265.72	.39
Total	$1,017.34	$2,169.45	$114.53	$3,301.31	$ .43

Table IV gives a comparison of the materials handled, the fuel required, and the total cost per M.G. for incinerator operation for each of the years since the Dayton plant has been in operation. It will be noted that there has been a gradual increase in the operation cost per M.G. for the past three years. This may be attributed to the fact that, since the fuel does not actually cost anything, less care is exercised to be economical in its use. The actual operation and maintenance cost during the past year was 30 cents per M.G.

Table IV—Operation Summary

	Material Handled		*Fuel*		
	Cu. Ft. per M.G.	*Lbs. per M.G.*	*Cu. Ft. per hr.*	*Cu. Ft. per lb.*	*Total Cost per M.G.*
1930	2.3	132	2265	4.4	71 cents
1931	1.94	113	2780	4.7	52 cents
1932	1.95	112	1740	2.2	50 cents
1933	1.92	117	1125	1.6	35 cents
1934	2.09	122	1250	3.0	41 cents
1935	1.69	98	1973	3.5	43 cents

The Dayton treatment plan is an Imhoff sedimentation type plant, with glass covered sludge beds and gas collection from the Imhoff tanks. The dried Imhoff sludge is processed and sold as fertilizer. A secondary treatment plant, consisting of twenty 165-foot rotary distributor trickling filters and four 80-foot final settling tanks, is under construction as a WPA project.

The maintenance of all city sewers, the operation and maintenance of the sewage pumping stations and the operation and maintenance of the sewage treatment plant are financed by sewer rentals. This costs the average household $3.80 per year. The addition of secondary treatment will not require any increase in this charge. The Division of Sewage Treatment is a part of the Water Department. W. W. Morehouse is Director of this Department. F. O. Eichelberger is City Manager.

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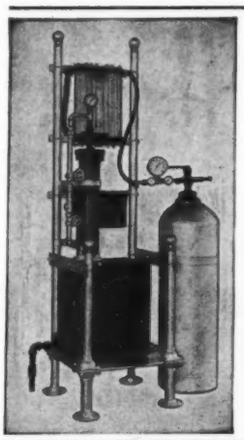

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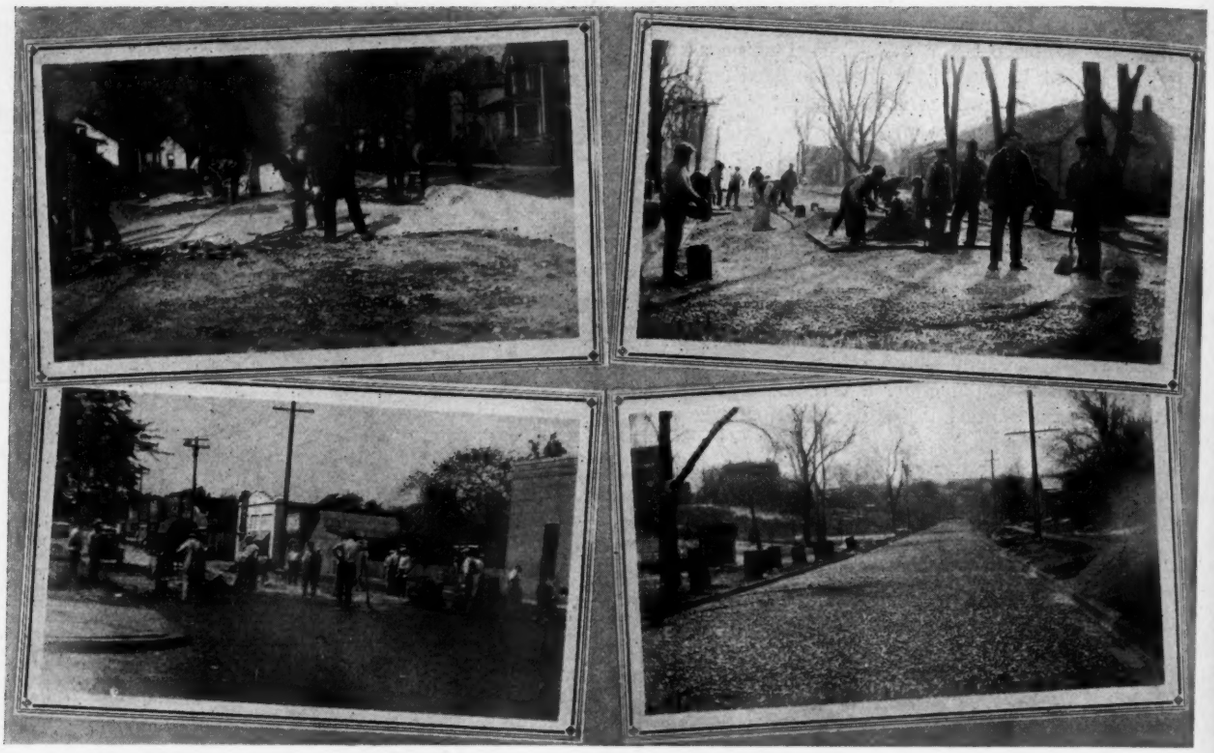

Some of the views of the work in Collinsville are shown above.

Asphalt Resurfacing by Cooperation

By JOHN B. VIGNA
Sup't. of Public Works, Collinsville, Ill.

A BRICK pavement in Collinsville, Ill., which has been under heavy service for 25 years, had become rough and badly worn. A street car track down the center of the street had settled, leaving the center of the street lower than the edges along the curb line. Also, the street surface had been laid without expansion joints, causing some of the brick to crush during hot weather, creating holes and bumps.

The idea struck me of visiting every property owner along this street and asking them how they felt about having their street resurfaced. I agreed to file a project with the government relief authorities, who had assured me a percentage of stone and asphalt, and all labor, but the property owners would have to pay the rest.

It took considerable time to work this up, as it was necessary to call on some of the property owners three or four times; some lived out of town, and required two or three letters; it was necessary to make some of the calls in the evening. Of course, most of them favored having a nice street, but did not know how they were going to pay for it.

A cost sheet was worked up, showing the estimated cost divided by the number of property owners; I figured this so that every owner would pay the same amount, regardless of corner lots or size of lot. A further complication was that some could pay cash, but others were unable to pay all at once; these were willing to pay on a monthly plan. The city could handle it only by special assessment, requiring court costs. Material men did not care to wait for their money, but the banks agreed to work with me if the property owners would sign notes to pay either cash or on the monthly plan with 6% interest.

Mr. Vigna

The street cost the property owners $25 each, plus interest. The surface is 28 feet wide. For the base, ¾-inch stone was used, mixed on the brick pavement by hand, using 15 gallons of asphalt per ton of stone, followed by a seal coat using ⅜-inch stone mixed with the same amount of asphalt. After placing, this was tempered for 12 hours, and rolled with a 7½-ton roller.

Before laying the asphalt surface, a row of brick was taken out at each intersection, and also midway in each block, and the space filled with asphalt and stone, thus providing expansion joints.

We also resurfaced about 1¼ miles of old water-bound macadam, using the same plan with a cost to property owners of $40 each. This street is 32 feet wide. About 3 inches of the old base was removed before applying the asphalt and stone mixture, so as to give a clean base and firm bond with the new surface; and also to maintain the proper crown and section.

Both of these streets have held up very well under heavy traffic, and have proved very satisfactory.

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Practical Kinks for the Engineer

Contributions to this page are invited. Send in your kinks. Public Works will pay $3 each for those published.

Protective Guards for Shrubbery From Fruit Crates

DURING the earlier stages of the growth of many decorative shrubberies, a substantial protective framework of some kind around them is a necessity. Where special departments and facilities are in charge of landscaping and building maintenance elaborate provisions are usually made. In many instances, however, it costs considerable in time and expense for special material. Old grape fruit crates can be made use of in a very practical manner. Carefully knock them apart. The ends and center portion of the crates are a stronge tongue and grooved square frame, quite large enough. Simply rip the long side strips into sticks some 1½" wide, sharpen one end and tack to one or more of the frames. Push the pointed sticks firmly down into the ground. Nails from the crating can be used to apply the side or anchoring sticks. In this very simple and easy manner, quite a number of such guards can be quickly and easily put together with but little or no expense.

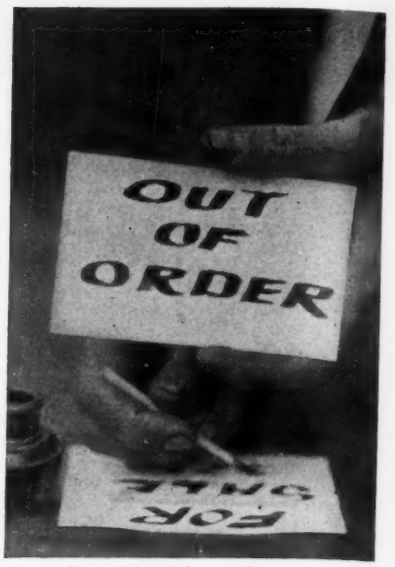
Snuff Box Makes Handy Device to Clean Cloth Tape Line

THE handy and convenient cloth tape line, used commonly where extreme accuracy is not a requisite, is very difficult to hold while cleaning, though the dirt and other discoloring matter in the fabric can be easily worked off and out with a piece of ordinary soft art gum. It is difficult to hold the tape on any flat surface, and the dirt as it comes out must be immediately carried away, as the gum tends to work it right back into the slightly roughened weave, dimming the numerals and division marks. A very handy and practical method of cleaning such a line is shown above. Lay and hold it snugly over the side of a common snuff box. It is easy for the fingers to hold it in this manner. The cleaning gum is readily worked over the tape, the dirt from both dropping down clear and free of the surface as soon as it is loose. The above method, easy to use, will permit a quick and thorough cleaning of the tape.

Common Paraffined Soda Straw for Brush on Sign Work

By F. W. Bentley, Jr.

NEAT and artistic card writing and sign work is a skilled trade to be sure, and calls for long and continued practice with brush and inks. However, the job of making some kind of a sign on the need of the moment often falls to many of us, when we are without a brush of any kind, and with not much ability to use one if we did have it. Yet a common paraffined paper soda straw can be flattened for a short length, dipped in ink or some other coloring pigment and some very neat and clever amateur work executed. There is something about a stiff flat point of marking edge which seems to help out the most clumsy efforts at lettering. When the point softens through contact with the card and ink, cut it off, compress some more of the straw and keep on with the job. One or two "swipes" at the card will surprise you at the neatness and legibility of a card which an untrained hand can turn out with this handy and practical substitute for a small brush.



Lettering with a soda straw.

Motor Driven Pump Keeps Ditch Dry for Laying Tile

By H. A. Andress

IN digging a 16-foot ditch in sandy ground it was found that water filled it to a depth of three feet. So a novel pumping arrangement was designed, making it possible to continue the work in a dry ditch. The manifold being a 4-inch pipe in three sections, each section connecting to ten wells, so that as the work progresses the rear section can be moved forward and connected without disturbing the other sections. The wells consist of an ordinary well point, driven four feet deep and connected to a manifold, each connection having a gate-valve, so that any number of wells that are required can be used at any particular section of the work. The manifold is connected to a centrifugal-pump powered with a three horse power gas engine.

Arrangement of wells and connection to manifold.

The snuff-box for cleaning tapes; method of use.

Views of the work on S. Saginaw St., Flint, described in this article.

Repaving and Other WPA Projects in Flint

By OTTO K. PHILIPP
Office Engineer

THE repaving of S. Saginaw St., Flint, from 5th St. to Water St. is a part of the 1936 Federal Aid Program of the Michigan State Highway Department. The beginning of the work on March 16th came after nearly a full year's efforts on the part of the city officials to have a portion of the Federal Aid funds expended for the benefit of the city. Approval of the city's request was announced in May, 1935, before expenditures on the Federal Aid Program for 1936 had been authorized, but action on the work was delayed because a definite decision regarding continuation or removal of street railway tracks was not arrived at until too late in 1935 to begin work. But early in 1936 a contract calling for completion of the work by August 1st was awarded by the State Highway Department.

The project involves removal of the present 67-ft. pavement, a part of which was constructed in 1897 and a part in 1914. Street car tracks are being removed as a part of the contract and the surface replaced with approximately 21,000 sq. yds. of brick surface laid on an 8-inch reinforced concrete base course. The street is being narrowed to 60 ft., providing for six traffic lanes which, with the removal of the street car right-of-way, will provide greater facilities for traffic than the old pavement and will increase the sidewalk width, which in this section of the business district is, at times, inadequate. The approximate cost of the entire project is $140,000.

Removal of the pavement between Water St. and Fifth St. in preparation for repaving disclosed unfavorable soil conditions, the added work necessary to correct which has increased the cost to the State as well as to the City and the utility companies.

Saginaw St. which, according to the State traffic survey, carries the heaviest traffic flow in Michigan, has been the principal north and south route from Detroit to Saginaw and Bay City ever since the development of the Northwest Territory began. Within a hundred yards of the bridge over Flint River on U. S. 10, immediately north of the end of the repaving project, was located the "Grand Traverse of the Flint River" where the Indians, as well as all pioneer traffic to and from the fur-trading posts in the north and the big lumbering developments of Michigan, crossed the stream at a ford now long since obliterated.

With the growth of the Village of Grand Traverse near this stream crossing and its incorporation as a village and later as the City of Flint, came the demand for a bridge and the establishment of a grade for the highway on either side. The elevation above the stream necessitated a fill which is estimated to have exceeded twelve feet in depth near Water St. Sawmill "tailings" have been observed in excavations for building foundations along Saginaw St. at a level corresponding to this depth, and it is quite probable that such materials, along with whatever waste was available for fill, was deposited in the street. Further evidence of the unsuitable character of the fill is indicated in the minutes of the first meeting of the Common Council of the City of Flint on April 15, 1855, wherein the deposit near the abutment was described by a complainant as "a very offensive nuisance." Recently near Third St. a corduroy logging road was encountered at a depth of approximately 7 ft.

Most of the roadbed has become stabilized by the action of traffic and is not subject to any appreciable

further settlement. In the section between Water and Union Sts., however, inadequate drainage which allowed moisture to accumulate under the foundation in the clayey subsoil, containing organic matter, brought about disintegration and decay. Vibration due to the heavy loads on the railroad and the impact of street cars and heavily loaded trucks contributed in creating a bad condition. It was inspected by the soil specialist of the State Highway Department, who ordered the removal of the unstable subsoil and its replacement with suitable material. Fortunately, a considerable quantity of proper filling material was available in the foundation of the old pavement south of Second St. This consisted of broken stone and gravel mixed with the Natural cement used before Portland cement was developed. More than 1,000 subic yards of this material was used as backfill.

Another difficulty was encountered in this section when lead water service lines were uncovered for the purpose of inspecting their condition. It was found that they were almost completely disintegrated from the effects of electrolysis in the soggy soil and from the constant vibration of traffic. South of Kearsley St. the drainage was more adequate and no effects of electrolysis were observed. These lead pipes were replaced with copper lines and the trenches backfilled with gravel and sand. Every reasonable precaution has been taken to insure a subsoil foundation adequate to support a permanent pavement structure.

Other WPA Projects in Flint

Repair and resurfacing of asphalt pavements.—The City's operating finances, under the 15-mill tax limitation, have been so reduced that adequate pavement maintenance has been impossible. As a result, normal wear of asphalt surfaces created a condition in which travel was unsafe and complete disintegration of the surfaces within two or three years was imminent. A WPA project involving the repair of nearly 60,000 sq. yds. of surfaces has gone far toward restoring our asphalt paved street system to the desired standard. This project, involving nearly 500 man-months of employment, and materials and equipment costing nearly $70,000, was completed early in the year. A supplementary application for similar work involving a still greater area of surfaces, is now under way.

Earth and gravel streets.—Many unimproved streets were not maintained regularly during the past five years, and as a result, gutters became filled and overgrown, surfaces worn and pitted and the roadways generally depreciated. The flow of surface water caused erosion and wash in the gutters to the extent that the side ditches were a hazard to traffic. Much of this has been done away with under a project involving work along nearly 35 miles of gutters. A much larger and more complete project covering nearly 300 miles of streets has been started and is expected to restore our unimproved street system to a safe and satisfactory condition for local traffic.

Bishop Airport.—This project involves installation of a complete and modern lighting system with materials made available through the generosity of Arthur G. Bishop, a local aviation enthusiast. The project also includes runway surfacing and grading, together with the construction and installation of many essential appurtenant structures and devices.

Sewers and Sewage Treatment.—Sanitary sewer construction projects now under way in the northeast portion of the city will provide sewer facilities for a rapidly developing area where this essential improvement has heretofore been denied. The area, occupied for the greater part by a low wage earning group, whose ability to finance special assessment work is limited, will require nearly 70 miles of lateral sewers for its complete development.

At the sewage treatment plant a project is under way to provide added sludge drying facilities. The original sludge beds have become seriously overtaxed, due to their use for drying tank skimmings.

Small streams.—The flow in creeks and drainage outlets has been hindered by the accumulation of weeds, brush, rocks and other obstructions, causing overflows onto adjacent low lands and considerable damage. Shallow pools cause mosquito breeding.

Sidewalks.—The condition of many public sidewalks, for which the property owner is responsible, has become hazardous, due to the lack of maintenance during the past four or five years. The City of Flint has not deemed further special assessments justified at a time when taxpayers are already overburdened with delinquent taxes; but it does not believe that the owners will object to an assessment covering the cost of materials and equipment only, and has accordingly applied for a project involving the repair of more than 100,000 sq. ft. of defective walk, planning to re-lay sections and eliminate frost heaves, grade settlements, bad effects of tree roots, worn out areas and defective or disintegrated surfaces.

Other projects.—Other applications made include the investigation of asphalt pavement surfaces throughout the city to determine and identify the properties of sheet asphalt pavement constituents under varying traffic, age and service conditions, to study their relationship to the original quality requirements and to investigate causes for success and reasons for failure of particular examples. The data collected will be used to develop rational specifications necessary to insure satisfactory service behavior on asphalt surface streets.

Another project in the white collar classification which has been approved involves the searching of the files in the Register of Deeds' office and the Common Council proceedings for the purpose of compiling a complete, accurate record of property owned or controlled by the City. Two applications have been filed to cover the relocation of the city market. It is planned to remove the buildings and re-erect them on a new site, clean up and grade the existing location and convert the property into a free parking lot, which is badly needed in the downtown district.

Different Media of Percolating Filters

Six years' operation of three percolating filter beds, each filled with a different medium but all receiving the same sewage at the same plant, gives an opportunity for comparing the relative effectiveness of the different media. The plant is at Chorley, England. The media are gasworks coke, clinker from the destructor works, and broken sandstone; all rejected on a 2½ in. and retained on a 1¼ in. screen. None of it was washed, and for several years small particles of coke washed from the coke filter, and grit from the sandstone is still washing out, after 9 years' service. Sludge from the secondary tanks had to be pumped, and the grit gave considerable trouble with pump valves and plungers.

On the basis of oxygen absorbed in 4 hours, the averages for the six years were: Primary tank effluent 49.9 ppm; effluents after one hour's settlement from coke 8.5 ppm, clinker 10.1, and sandstone 11.9. Solids in suspension were: From coke 78 ppm, from clinker 76, from sandstone 94. Thus coke is easily the best and sandstone far the worst of these three materials.

A Digest of the Sewerage Literature of the Month giving the main features of all the important articles published

The Digestion Tank

Centrifugal clarification (if experimental work and claims can be proven) "offers possibilities of eliminating digestion tanks, sand drying beds, etc. and centrifugal sludge 'wringing' in conjunction with incinerators can be utilized for the complete disposal of all sludges derived in the treatment of sewage." "The work of centrifugal dewatering devices commences at the point at which the work of gravity ceases.—A centrifugal clarifier is capable of separating suspensions which will not separate further by the force of gravity alone under any condition."

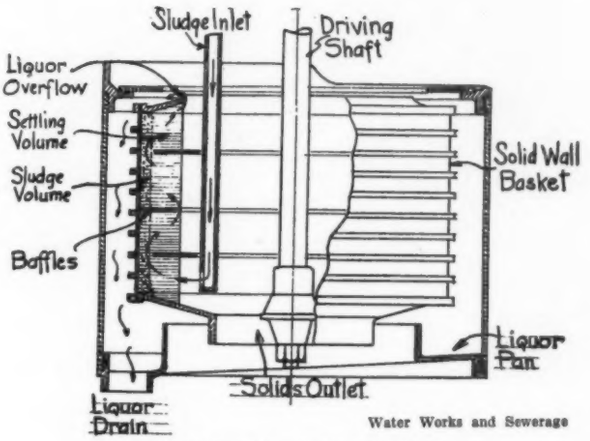
Centrifugal extractors remove solids from the liquid by discharging it through perforated baskets or filters which retain the solids. In centrifugal clarifiers the liquid does not pass through a retaining membrane or medium, but separation takes place by virtue of the difference in density or specific gravity of the suspended solid and the liquid. In the type of machines now built it is almost imperative to maintain the initial concentration of the entering sludge at a constant figure, as otherwise the controls must be constantly readjusted to meet the variations in concentration. Conditioning of sludge prior to dewatering has not proven to be of material aid in the separation of the solids. The filtrate from centrifugal clarifiers may have a suspended solids content and a B. O. D. many times that of the raw sewage and its return to the raw sewage may have a deleterious effect on its treatment. One plan is to thicken the sludge before centrifuging and return the filtrate to the thickener tank.[G6]

Filter flies are controlled at Huddersfield, England, by mixing 14 lb. of sewage grease, 20 gal. of creosote and 20 gal. of 1% solution of soda ash, and feeding this into inlet valve of filter at the rate of 1 gal. to 87 sq. yd. of filter surface, giving a mixture of emulsion and tank liquor that contains not more than 0.5% of creosote; the treatment being applied every day for 30 days, and then on 3 consecutive days at fortnightly intervals all summer. Cost about 4 cts. per sq. yd. per year. Gives almost complete immunity.

At the same plant 2 gal. of ortho-dichlorobenzene added to the feed pipe of a 100′ diam. distributor on 10 consecutive days gave immunity for a month, giving about 1 gal. to 200 sq. yd. of filter. This does not give complete immunity. When first applied it drives out any flies in the bed and these are disposed of by spraying filter walls and paths with a 1:3 mixture of creosote and paraffin. (At Bury this treatment had a distinct retarding effect on the purification from which it took more than a week to recover.)

In another experiment, lime and sulphate of ammonia were used to generate ammonia *in situ*, which killed the larvae and did not affect filter efficiency.[D12]

Peak sludge loads are a very important factor in designing treatment plants, especially where raw sludges are filtered and incinerated direct. In such cases a 2-day sludge storage or thickening period is advisable, and excess filter and incinerator capacity may have to be furnished to handle three or four times the daily average dry solids load. Installation costs are highest where peak loads of 375% of the daily average dry solids load are assumed; are higher for raw sludge incineration using 125% peak loads than for digested sludge filtration without incineration, but slightly lower than filtering and incinerating over 15 mgd of digested sludge, or than filtering and incinerating mixed digested primary and undigested activated sludge. Installation costs are lowest where all of the sludge is digested prior to dewatering on vacuum filters, except for filtration of the combined digested primary and thickened undigested activated sludges.



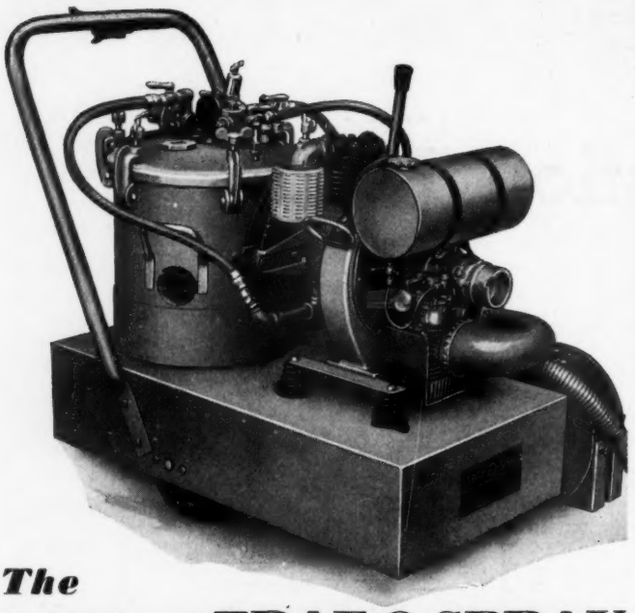
A centrifugal machine of the solid bowl type.

Operating costs are highest for raw sludge incineration plants even though providing for only 125% peak loads; and are lowest, for plants of less than 10 mgd capacity, where open sand drying beds are used; and for plants of over 25 mgd capacity, for digested sludge filtration or filtration with incineration.

Future trends appear to be toward vacuum filtration of sludges in the smaller plants, possibly drying the sludge cake for sale as fertilizer. In the larger plants sludge incineration will find more widespread application.[G3]

Aluminum alloys for use in construction in various parts of the Indianapolis treatment plant have been subjected to test under 10 different conditions in the plant: Submerged in septic raw sewage; in air above same; submerged in fresh raw sewage; in air above same; submerged in an aeration tank; in air above same; submerged in activated sludge effluent, in activated sludge, in digesting sludge and in the air above digesting sludge. Four different wrought alloys and four cast were tested at each place for 11 months.

The test indicated that "at Indianapolis aluminum is satisfactory for almost all purposes in the sewage plant," but some alloys are more suitable than others for certain locations. Consideration should be given to mechanical properties and cost, and whether cast or wrought metal is desired. Aluminum should be kept entirely insulated from other metals to prevent electrolytic action. Coating alloys with aluminum oxide, formed by placing the



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metal as the anode in an electrolytic bath of sulphuric acid, makes them more impassable than if not so coated.[H12]

Sewer inspection in Detroit is made periodically to find and remove deposits, examine the walls for leaks and the arch for breaks or flattening, and learn where repairs are needed to prevent further deterioration. There are 2,530 miles of sewer, some nearly 100 years old. Three boats are used in the investigation, propelled by poling. To safeguard the investigators, before they enter the sewer, experts make preliminary tests for poisonous gases in the air, entering the sewer equipped with oxygen gas masks and gas detectors and electric battery lights.

Things found in the sewers include jewelry, money, razors, revolvers, glass eyes, false teeth, cobblestones, tin cans by the thousand, wheelbarrows, bicycles, mattresses, babies and a bushel of golf balls. Rats and cockroaches are seen by the million.[H11]

Bibliography of Recent Sewerage Literature

c, Indicates construction article; *n*, note or short article; *p*, paper before a society (complete or abstract); *t*, technical article.

D *The Surveyor*

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7. Improving the Efficiency of Activated Sludge. By H. C. Whitehead and F. R. O'Shaughnessy, pp. 407-410.
8. New Method of Sludge Disposal (The "Porteous"), p. 418C.

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9. Strength of Sewage. By Dr. H. Bach, pp. 443-444.
10. *p.* Results Obtained From Sewage Filters of Different Media. By J. Slater, p. 444.
11. *p.* Preliminary Treatment and Inspection of Trade Wastes. By E. J. Shaw, p. 445.
12. *p.* Sewage Filter Fly Nuisances. By J. P. Todd, p. 449.

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13. *p.* Laboratory Tests for Ascertaining the Conditions of Activated Sludge. By E. Ardern and W. T. Lockett, pp. 475-476.

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14. *p.* Some Developments in Sewage Works Analysis. By C. Lumb, pp. 495-497.
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16. *p.* Some Problems of Trade Waste Disposal. By A. Sciver, pp. 525-526.

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17. *p.* Discussion of D16, pp. 559-560.
18. *p.* Design and Operation of Sewage Disposal Works in South Africa. By E. J. Hamlin, pp. 561-562.

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19. Storage Capacity in Sewer Design, pp. 587-588.

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3. The Economics of Various Methods of Sludge Disposal. By A. J. Fischer, pp. 69-77.
4. Gas Explosion Damages Bristol, R. I., Sewage Works, pp. 91-92.
5. Things to Consider in Selecting Sewage Pumps. By V. J. Mill, pp. 93-94.

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6. Centrifugal Dewatering of Sludges. By P. B. Streander, pp. 112-117.
7. *p.* Operating Experiences at Perth Amboy's Chemical Treatment Plant. By S. I. Zack, pp. 134-137.
8. Inexpensive Laboratory Floccer. By G. R. Frith, pp. 139-140.

H *Municipal Sanitation*

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9. Selecting Motors and Controls for Sewage Works. By V. B. Miller, pp. 160-162, 168.
10. *p.* Nickel Alloys in Sewage Disposal. By G. L. Cox, pp. 163-166.
11. Materials Found in Deposits in Sewers. By J. S. Stringham, p. 166.
11. Status of Sewage and Industrial Wastes Disposal in Colorado. By E. V. Howe. In Maine. By E. W. Campbell, pp. 167-168.
12. Aluminum Alloys Tested for Sewage Treatment Plant Use. By D. E. Bloodgood, pp. 169-170.
13. Durham, N. C., Sewage Plant Supplies City With Electricity, p. 176.

P *Public Works*

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10. *p.* Activated Sludge Developments in Great Britain, pp. 13-14.
11. Operating a Multi-Stage Sludge Digestion Plant, p. 18.
12. Chlorinating Sewage on Ships. By A. W. Sweet, p. 26.
13. *n.* Cost of Pipe Sewers During Forty-seven Years, p. 26.
14. Sewage Treatment for Summer Camps, pp. 43-46.

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1. *c.* Laying Lined Concrete Sewer at Columbus, O., p. 5.

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1. The Patent Situation in Sewage Treatment. By P. Hansen, pp. 61-65.
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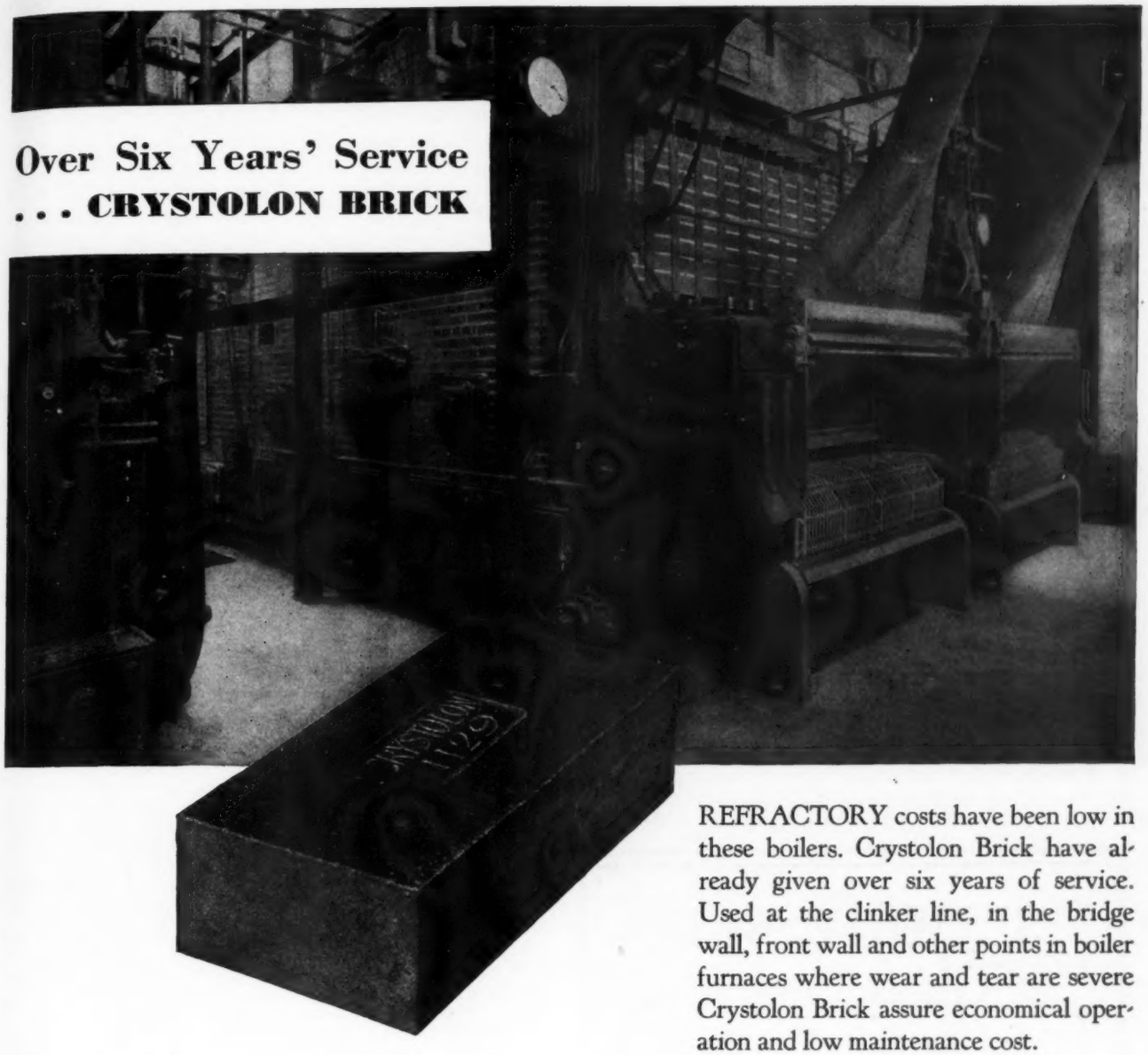

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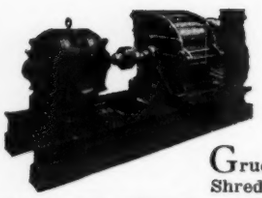

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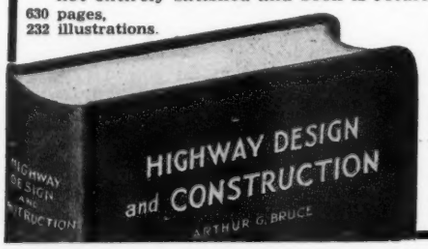

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The Survival of B. typhosus in Surface Waters and Sewage

Typhoid fever, though not so prevalent as in former years, still ranks as an important potential epidemic disease. The transmission of the causal organism, *B. typhosus,* by means of water has led to much research concerning its survival in water and in sewage. Recently a report was issued by the New Jersey Agricultural Experiment Station of work on this subject by H. Heukelekian, associate in water and sewage research, and H. B. Schulhoff, graduate student. The work, which was carried on under various environmental conditions, resulted in the following conclusions:

The rate of decrease of *B. typhosus* in polluted water and sewage is rapid. Several days' storage will result in a 99 per cent reduction with a heavy initial infection.

The rate of decrease is affected materially by the temperature, being greater at a temperature of 22°C. and 37°C. than at 2°C.

An actual multiplication of *B. typhosus* with favorable temperatures and in the presence of food supply may take place. This multiplication, however, does not necessarily result in an increase in the survival time, as the rate of decrease after the multiplication stage is greater than without an initial multiplication.

The addition to unpolluted water of small amounts of feces, urine, sewage and broth, and the food carried over in the inoculum from broth culture and agar slants results in actual multiplication.

The magnitude of the multiplication is dependent on the amount of food added.

In polluted waters the survival of *B. typhosus* is shorter than in unpolluted waters, probably because of the competition for food from other bacteria and because of protozoan attack.

Aeration reduces the survival time of *B. typhosus.*

Under starvation conditions the presence of *B. coli* does not affect the death rate of *B. typhosus.*

The survival time of *B. coli* is not affected by the presence of *B. typhosus.*

In the presence of food supply the survival time of *B. typhosus* is reduced by the introduction of *B. coli.*

The addition of flavobacterium increases the longevity of *B. typhosus* probable as a result of food made available by the former.

When a normal domestic sewage is sterilized with heat and infected with *B. typhosus* a rapid increase occurs initially. With certain sewages containing industrial wastes the initial increase does not take place and the survival time is greatly reduced.

With various municipal sewages no successful isolation of *B. typhosus* could be made from 0.1 cc. of sample.

A rapid reduction in the number of *B. typhosus* takes place during the anaerobic digestion of sewage solids.

When present in activated sludge-sewage mixtures the numbers of *B. typhosus* increase initially (4 to 6 hours). The increase is greater when no air is passed.

There is a very rapid reduction of the numbers of *B. typhosus* in the activated sludge mixtures after the initial increase, especially in the presence of air.

When artificially infected sewage is chlorinated partially, the destruction of *B. typhosus* is of the same order as the destruction of the normal sewage flora.

When only 25 per cent of the chlorine demand was satisfied, there was over 99 per cent reduction of *B. typhosus* in 10 minutes' contact time.

The investigators studied the survival of *B. typhosus* in different artificially infected substrates under various environmental conditions, using brilliant green agar for the enumeration of the numbers. The study was further extended to the presence of *B. typhosus* in sewage and the survival in sewage treatment processes.

The report includes a bibliography on the subject, listing 21 reports and papers by various authorities, beginning with Percy Frankland's "Microörganisms in Water" (1894), and coming up to a paper in the *Journal of Bacteriology* in 1935 by H. W. Gehm and H. Heukelekian. Among the authors cited are Ballantine, Butterfield, Purdy, Ruchhoft, Sherman, Fuller, Winslow and Whipple.

Refuse Collection in Indianapolis and Seventeen Other Cities

THE collection of ashes and garbage in Indianapolis is a function of the Collection Department of the Sanitary District. The department operates under the direction of a superintendent, who is directly responsible to the Board of Sanitary Commissioners.

The department operates a motor repair shop for the repair of all motor equipment used in collection work, and also for motor equipment used by the sewage and garbage disposal division of the sanitary district, and employs a suitable number of mechanics for this repair work. A shop for repairing trailers also is maintained.

For purposes of administration, the territory served is divided into districts, and the work in each district is directed by a supervisor, who reports to the superintendent. Complaints regarding service are telephoned to a clerk and are given to the supervisors for investigation and adjustment.

Dump trucks and tractors comprise the motor units used in the collection operation. Single dump truck units are used in the downtown area, while in the residential section either dump trucks or trailer trains are employed. Horse drawn trailers cover the territory in the residential districts collecting ashes or garbage and bring them to common points where they are assembled into trains and drawn by tractors to the points of disposal. The operation is continuous, sufficient units being employed to permit the loading of trailers while the loaded and empty trains ply back and forth.

For the operation of a tractor and trailer unit, one driver and one helper are required. For each trailer, during collection, there are required one team and driver, and two or more laborers. Teams are hired by the hour. Collections are made in the alleys, where alleys are improved, and at the curb in other districts. Householders are required to place the garbage and ash receptacles in the proper location on collection day.

Ash collections are made once each week in the winter, and every two weeks during the summer. Garbage collections are made once each week during the winter, and twice a week during the summer, with daily collections from the business district. Tin cans and similar rubbish are collected along with ashes. The term "ashes" as used in this report generally includes tin cans and similar rubbish, usually non-combustible, while the term "garbage" may or may not include paper and other combustible material, depending on the method of disposal.

Garbage is hauled to the garbage disposal plant at Eagle Woods, while ashes are disposed of as fill, in dumps located wherever suitable areas can be obtained.

Unit costs of ash and garbage collection for each of the past ten years are:

Year	*Ashes Per Cubic Yard*	*Garbage Per ton*
1925	$0.647	$3.136
1926	.736	2.906
1927	.732	2.919
1928	.795	3.016
1929	.763	2.901
1930	.691	3.265
1931	.646	2.916
1932	.707	2.505
1933	.575	2.847
1934	.632	3.119

The low cost during the years 1931, 1932 and 1933 may be attributed largely to the use of relief labor furnished by the Emergency Work Committee. With the establishment of the FERA, early in 1934, the use of this labor in collection was discontinued, with a resultant rise in collection cost.

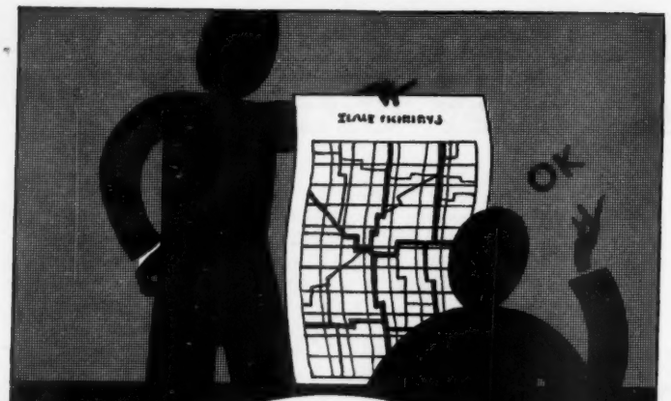
In the accompanying table are shown costs and other data from Indianapolis and seventeen other cities.

A diversity of factors influence collection costs: Whether the garbage is collected wet for reduction or hog feeding, or dry for incineration; types of collection equipment; length of haul; location of waste receptacles; wage schedule; etc. Therefore, only a very general comparison can be made, subject to interpretation in the light of those influencing factors.

Data on Ash and Garbage Collection

City	Ash Collection Cost Per cu. yd.	Ash Collection Cost Per Capita	Garbage Collection Cost Per Ton	Garbage Collection Cost Per Capita	Total Cost Per Cap.	Tons of Garbage Collected Per 1000 Population	Average Length of Haul-Miles Ashes	Average Length of Haul-Miles Garbage	Location of Receptacles
Detroit, Mich.	.73	.798	6.41	.542	1.340	83.58	10	4	Rear steps (8)
Cleveland, O. (1)	.905	.534	4.128	.407	.941	90.56	2	4	Rear steps
Baltimore, Md. (2)	1.31	.311	3.81	.361	.672	94.81	3	10	Curb & rear (9)
Milwaukee, Wisc.	1.056	1.02	5.73	.428	1.448	74.67	..	4	Alleys & rear
Buffalo, N. Y. (3)	2.359	...	2.359	...	1.298(6)	161.55	3	5	Rear steps
Minneapolis, Minn.	...	...	5.48	.407	...	74.23	..	..	.....
Cincinnati, O.	.55	.395	3.44	.665	1.060	193.39	3	3	Rear steps (10)
Indianapolis, Ind.	.632	.279	3.119	.217	.496	69.60	2.5	5.5	Curb & alley
Seattle, Wash.	...	...	2.67	1.001	...	374.73	..	2	Near rear
Rochester, N. Y.	1.10	1.466	3.08	.344	1.800	108.80	..	2.2	Rear steps
Louisville, Ky.	...	...	...	...	1.019(6)	....(7)	5.8	2	Curb & alley
St. Paul, Minn. (4)	...	...	7.37	.196	...	....	..	5	Rear
Akron, O.	...	...	3.89	.325	...	84.40	..	10	Rear steps
Syracuse, N. Y.	.39	.471	2.625	.290	.761	110.54	..	2	Rear steps
Dayton, O.	.315	.191	2.12	.333	.524	156.28	..	2	Curb & alley
Kansas City, Mo. (5)	...	...	6.45	.921	...	142.83	..	..	.....
Denver, Colo. (5)	...	...	.15	.043	...	276.46	..	12	Alley
Omaha, Nebr. (5)	...	...	2.37	.140	...	160.74	..	30	Alley

(1) Cleveland costs are for labor only; (2) ashes are expressed in tons; a cubic yard of ashes weighs 1200 to 1800 pounds; (3) ashes expressed in tons, and costs for ash and garbage collection are not separated; (4) St. Paul collects only about 1/3 of the garbage, the remainder being collected by private scavengers; (5) these cities provide for collection by contract between municipality and private concern; costs are not comparable; (6) ash and garbage costs are not separated; (7) no record of qualities kept; (8) ashes are usually collected from the alley; (9) 30% from curb and 70% inside rear gate; (10) on curbs in downtown basin district.



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The costs in Indianapolis are shown to be low. One reason for this is the low rate paid for labor. In Indianapolis, this rate is 40 cents an hour—lower than that reported by any other city except Louisville. In general, Indianapolis labor costs are 30% lower than the average for other cities. Another reason for the low per capita cost is that a smaller amount of garbage is collected per capita than in any other city reporting. With less garbage to collect, the per capita cost should be lower.

At least 20% of the garbage in Indianapolis is picked up by farmers. Smaller proportions, as follows, are collected in other cities by farmers: Detroit, 8%; Milwaukee, 4%; Buffalo, 2%; Cincinnati, 5%; Seattle, 3%; and Dayton, 5%.

The larger amounts collected in Buffalo and Cincinnati are probably due to the practice of collecting some combustible waste with the garbage, in order to aid in incineration.

The data in this article are taken from a report by the Bureau of governmental research of the Indianapolis Chamber of Commerce.

Gradient or By-Pass?

The relation between traffic speeds and transport efficiency (in tons per km. per hour) is examined for speeds of 3, 25, 37½ and 50 m.p.h. The markedly greater efficiency at higher speeds, together with the accompanying decrease in the proportional expense due to wages, etc., must be taken into account in evaluating the probable economy effected by the elimination of steep gradients. The influence of the gradient on fuel consumption has been investigated theoretically by Benz and practically by Kluge and von Sanden; the latter workers found that at the respective speeds of 12½ and 22½ m.p.h. a gradient of 1 in 25 caused increases of 61 and 51 per cent in fuel consumption, whilst in the case of a gradient of 1 in 16 the increases were 90 and 75 per cent. The financial loss caused by avoidable gradients is estimated for an average daily traffic load of 1,000 vehicles, and it is shown that one mile of road with a gradient of 1 in 25 is economically equivalent to 1⅓ miles of flat road. The expense of constructing by-passes or of otherwise eliminating gradients is hence fully justified. *Road Abstracts,* D. v. Haselberg: *Strassenbau,* 1935, **26** (21), 315-7.

Proteus Process of Sludge Disposal

Several experimental plants using a new process of sewage treatment are being operated in England—at Wandle Valley, Halifax, Sheffield and Bradford. This, the Proteus process, consists of heating primary tank sludge to a high temperature under steam pressure and then dewatering in a pressure filter. Sludge of 95% water is coagulated and settles rapidly. The supernatant liquid is said to have no sewage odor, and the sludge can be pressed, in 20 to 30 minutes, to a cake with a water content of about 40%, which has no unpleasant odor. At the Wandle plant the sludge is subjected to a pressure of 150 lb., temperature not stated.

While it is said that the cost of this treatment is "relatively small for both capital outlay and working," raising all the 95% sludge of a plant to a "high" temperature and subjecting it to 150 lb. pressure, followed by pressing it in Johnson filter presses, cannot, it would seem to us, help but be a pretty costly process.

Removing Street Car Tracks with Relief Labor

By P. L. Brockway, City Engineer, Wichita, Kans.

THE city of Wichita, Kans., has removed from its streets practically all of 34 miles of street railway track (two-thirds in double-track streets), which had been constructed by a private company in 1910, 1911 and 1912. In 1934 a company organized by local citizens took over the assets of the original company and obtained from the city a new franchise which provided for substituting buses for the street railway and for taking up the abandoned tracks and to "restore the pavement to satisfactory condition"; the company finally agreeing to pay the city $75,000 and transfer title to all of the track structure to the city, which was to take up the track and restore the pavement.

Rate of Track Depreciation

The city was interested in learning the physical condition of the track because, in rate-making hearings, it has been common practice to assume a useful life of 50 years for track structure. The rails were of ordinary T section, most of them of the high or girder type, weighing from 55 to 70 lbs., except for some 90-lb. Santa Fe section laid recently. All except the two miles laid last was spiked to wooden ties spaced approximately 2 ft. centers, which were embedded in concrete 12 in. thick and extending the full width of the track. The last few sections were of ordinary T rail section welded to cross ties made of inverted T rails spaced 5 ft. centers, solidly imbedded in a concrete pavement 10 in. thick over the entire track area.

All of the track pavement had been laid under city specifications and contract and complete records of it were on file. Although well built, the company had had considerable difficulty in keeping the structure in good, safe operating condition. On many streets rails were loose, bolt holes in the ends of the rails being found split out, and the relatively thin sections of the rails were so badly corroded by moisture and electrolysis that few of the track spikes were holding the rail at all. It appeared to us that the depreciation was at least 3% and approached 4% per annum.

Plan of Reconstruction

The plan of the Engineering Department was to repave or resurface all the track area with a type of pavement similar to that on the rest of the street. A considerable part of the track area had been paved with brick with cement grout filler, while the rest of the roadway was sheet asphalt. On part of the asphalt streets, however, the track space had asphalt surfacing with nose blocks on the inside of each running rail and three or four rows of brick on the outside. In a few streets the track area was paved with brick, some with asphalt and some with grout filler, while the rest of the roadway was concrete pavement; and there were all possible combinations of brick, asphalt and concrete pavements. To further complicate the situation, all the older brick pavements had been laid with repressed block which were no longer on the market.

The department estimated that the reconstruction under these conditions would cost $225,000.

The city meantime had started negotiations with the Kansas Emergency Relief Corporation to furnish labor for this work from the relief rolls, which it did from Feb. 22, 1935, when the work began, until Sept. 5, when KERC passed out of the picture; and labor was obtained from WPA from the middle of November until the last rail was taken up April 8, 1936. From 100 to 200 men were employed under KERC and 200 to 350 under WPA.

Method of Prosecuting the Work

From an organization standpoint it was thought best to begin in the lesser traveled streets in order to train the men, most of whom had no experience in that type of work; also at all times so to coordinate the removal of the various types of pavement that stock of brick of the right type would be available to make up the shortage in those streets in which brick were replaced.

The most simple type of removal was where no effort was made to save the existing paving material. Here two ordinary 10-ton jacks were used, a hole being cut under each end of each rail and the jacks moved alternately from hole to hole down the street. No attempt was made to pull the spikes, and 95% of them remained in the ties. The brick pavement, especially that filled with cement grout, lifted with the rail and was knocked down with bars and sledges. The crews became so expert at this work that a crew of 6 men easily tore up a half mile of straight track in a day.

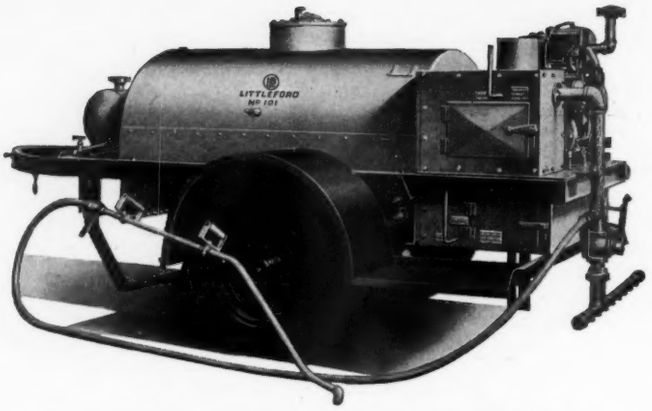
After the rails had been removed the joints (mostly composition joints with copper bonds) were cut apart, and the rails (in general 60 ft. long) were cut in two in the middle with a gas cutting torch for convenience in handling. The rails were then hauled to yards for storage and later cleaned and sold as scrap, bringing a total of about $18,000.

The brick removed were separated, hauled by trucks to a central yard and there cleaned, sorted and stocked for re-use in streets where there was brick paving on the outside of the tracks. The spalls, bats, sand and dirt were removed from the track area down to the tops of the ties and of the concrete between them.

Where there was asphalt pavement in the track area, also where the balance of the roadway was paved with brick, greater care was necessary to avoid tearing up an unnecessary part of the old paved surface. Here the general practice was to remove the nose blocks with picks, bars and sledges, with no attempt to save them as they had no salvage value; then to press the rail toward the center of the track as it was lifted, thus disturbing very little of the pavement outside the tracks.

Repaving With Asphalt

In restoring the pavement with asphalt, a black base was used on top of the ties, the coarse aggregate for which was made by running broken brick, nose blocks and spalls through a No. 2 gyratory Austin crusher, and was used unscreened. In warm weather this aggregate was mixed with bank sand and cutback asphalt in an ordinary concrete mixer, hauled to the street and spread in the grooves, and compacted by the traffic which was turned onto it at once. In winter the coarse aggregate and sand were run through a hot mix plant and the black base was made by the hot mix method, and compacted by means of a 10-ton roller. Some of this base carried traffic for as much as two months before the surface was applied, without excessive spalling. The final surface was standard sheet asphalt mix 2 in. thick



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on the principal streets in the downtown district, and from 1¼ in. to 1¾ in. in the lighter traveled residential streets. This was the most successful type of restoration, because asphalt can easily be patched with new asphalt without leaving an unsightly scar down the street. In some double-track streets where the old asphalt in the track area was badly checked up a new surface was laid over the entire track space.

Repaving With Concrete

In the relatively small mileage where brick track pavement was located in a concrete street, the space to be paved was cleaned out down to ties with considerable care before placing the concrete. The concrete used was the present standard mix good for not less than 4,000 pounds. Some slight reinforcement was used, especially in the wider places and where traffic is heavy. Expansion joints were placed in line with those on either side. The appearance is very good, although the center strip varies slightly in color and texture from the other and the new concrete is somewhat better than the old.

Repaving With Brick

The most difficult replacement was where the pavement was cement-filled brick. Most of the brick were excellent repressed type about 3 in. wide, 4 in. deep and 8 in. long, which had been furnished by practically every brick plant in the territory, no two makes of the same size but varying as much as ⅜ in. in thickness and length. The cement grout was so sound that probably one-third of the brick broke before the grout would, in spite of all possible care and supervision.

Cleaning the brick was the next major problem. At times as many as 200,000 were stored in the yard to be cleaned. During winter weather too severe for outside work, the entire gang was furnished with brick hammers and worked in a large building, kept at a livable working temperature by home-made gas heaters which consisted of a mixer with an open ⅜ in. pipe extending into an oil barrel from which both ends had been removed and which was filled with paving brick. While the working conditions were not ideal, there were no ill effects, but the men were restless because practically all other jobs were shut down. As the brick were cleaned, they were sorted into the different types and also into brands, so as to use on each street brick matching the old pavement as nearly as possible in size, color and type.

The next big difficulty was the practical impossibility of trimming the edges of the battered-down brick along the tracks to a straight edge. Laying brick lengthwise, crosswise and diagonal to match the brick on the outside were tried. In time the green men were taught some semblance of skill in cutting bats to the right length and patching the uneven spaces. It was even a major problem to train the men not to walk in the sand bed after it had been prepared for laying the brick.

At first the sand bed was mixed with some cutback asphalt, but the expense did not seem justified and straight sand tamped and screeded was adopted. Removing and cleaning the brick so scarred them that the patches are necessarily somewhat rough and uneven and an excessive amount of asphalt filler was used in pouring the joints. Asphalt was used regardless of the filler which had been used in the original pavement. After the first month or two a 2-ton roller was used to roll all brick laid.

On one of the older streets, all of the bricks in the track area were taken up and relaid in the same area after being cleaned. A brick-laying crew could lay as many feet of track a day by this method as by patching in grooves, but it required an excessive amount of haul-

ing of brick to the cleaners and back and much more asphalt filler. Cleaning on the street was found to be impracticable—men were constantly in each other's way and it was impossible to leave the street safe for traffic during the frequent stormy days when the men were not at work.

The question was raised a great many times about the advisability of leaving the wooden ties in place. Most of the ties were untreated white oak, which had been in place for twenty-five years. In a few places it was necessary to tear out the entire track structure to restore the contour of the street at the turnouts into private property, and here we found the ties astonishingly sound, somewhat water-logged but with no signs of decay. Spikes were generally quite tight in the ties, although they could be withdrawn easily after they were broken loose. Our opinion is that the placing of the new pavement over them, they being imbedded in concrete, will further preserve them for a period as long as the pavement on the rest of the street will last. There were very few signs of breaking up of the base even at those places where the rail ends were loose and working up and down.

As a matter of unusual procedure, the superintendent of the Transportation Company together with some of the W. P. A. officials and the city officials removed the last spike and the last rail with appropriate ceremony. An old car wheel rim was imbedded flush with the pavement at the spot, the web having been cut away. Within this rim was placed a bronze tablet commemorating the various steps in transportation in the city and imbedded around it were the last spike and with it a number of other spikes placed by officials, all as a monument to an abandoned passing stage of urban mass transportation.

Cost of the Work

That should be a good closing paragraph, but from the engineer's standpoint the following figures will probably be of some interest.

The total actual cost is as follows:

By KERC	$ 47,000
By WPA	81,000
By the City under KERC	35,000
By the City after KERC	56,000
Total	$219,000

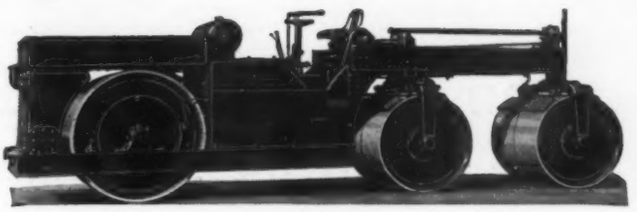
The rail salvage has been about $18,000, making a gross income to the city of $93,000, including the $75,000 received from the Transportation Company. The total expense to the city was $91,000. A more complete replacement of pavement was done than had been contemplated at less than the estimated cost.

Some of the principal items of expense to the city were as follows:

Asphalt paving filler	325 tons
Cutback asphalt	55,000 gallons
Sheet asphalt surface	4,600 tons
Hot-mix binder	3,200 tons

The city spent somewhat over $2,000 for small tools, $500 for lanterns, $400 for acetylene and oxygen, $800 for kerosene and gasoline. It was not possible to obtain skilled asphalt workers from relief rolls, and the city had a payroll of about $3,500 for this item.

Final results are much better than we had anticipated, and we believe that it is one of the best work relief projects which the city of Wichita has undertaken. It would have been very difficult to have handled it in any other way because of the extreme difficulty of financing it. It was not a job in which hand labor was substituted for machinery in any sort of boondoggling because it was essentially a hand labor job from beginning to end.



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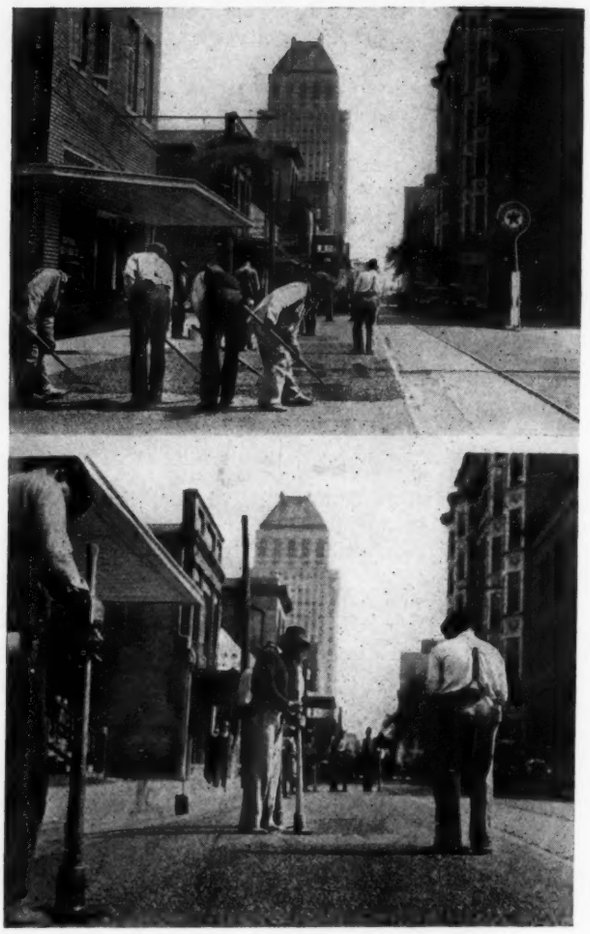
The Resurfacing of St. Francis Street

By HARRY L. FISHER
City Engineer, Mobile, Ala.



Laying and tamping the asphaltic surface.

ST. FRANCIS STREET leads from the heart of the business district of Mobile westwardly to the residential section. The street railway line, which traverses its entire length, carries more street cars than any other line in the city.

The street paving was in a very disreputable condition and the street car tracks had deteriorated to such an extent that something had to be done at once. Accordingly a WPA project was approved to resurface the street and to reconstruct entirely the railway tracks; all to be done with WPA labor except the track work; while the city was to furnish the technical supervision.

The Mobile Light & Railroad Company furnished the track material and supervised the work of relaying their tracks.

The first block from St. Joseph to Conception Street was originally paved in 1904 with sheet asphalt on a concrete base, and was resurfaced with approximately one-half inch of wearing course only.

The second section, from Conception to Claiborne Street, a distance of three blocks, was paved in 1906 with paving brick laid directly on a sand base, and had an integral curb and gutter. As the railway tracks fixed the grade in the center of the street it was found necessary to remove all the bricks and take out enough of the sand base so that the bricks could be replaced approximately 1½ inches below the original grade. These were then hand-tamped into place and thrown open to traffic until all movement of the bricks had ceased. The brick surface was then covered with 1½ inches of cold mix asphaltic concrete, using slag as an aggregate. One inch of binder was used, followed with a wearing course of ½ inch.

All of the asphaltic material was hand-tamped, as no roller was available. Some of this material was placed in cold weather, which made it exceedingly difficult to handle and it was necessary to resort to picks and shovels in order to cut the material. Good results were obtained with inexperienced labor in this class of work.

The third section from Claiborne to Broad Street, extending over a distance of ten blocks, was originally paved in 1910 with 3-inch creosoted wood blocks on a concrete base, with a 1-inch intervening cushion of sand. This was repaved with one-course 1:2:3 concrete. High early strength cement was used throughout and the street was opened to traffic from 24 to 48 hours after being poured. The mixing was done with two 5-foot concrete mixers; the mixers being placed at the intersection of the streets where the paving materials were

Concrete section showing longitudinal expansion joints.

assembled and transported from the mixer by wheelbarrows. All the labor used in this work was totally inexperienced and accordingly it was deemed necessary to lay out the work so that sufficient forms were placed in order that the concrete could be levelled off by screeding.

The street railway was first removed in its entirety and was replaced by using a slag ballast, creosoted ties and a heavy paving rail. The spaces between the ties and underneath the rail were poured with concrete so that the tracks were supported on a continuous beam. In this section, the concrete was brought up from the base of the rail and was poured at the same time as the aforementioned beam under the rail. At the outer edge of the ties and at the point where the old concrete base was broken through in order to remove railway tracks, a ¾-inch expansion joint was placed parallel to the rail on each side of the track, and transverse expansion joints were placed at 25-foot intervals extending all the way across the street.

With the exception of that portion of the street that was removed for replacing the railway tracks, the old concrete base was not disturbed. After the wood blocks and the sand cushion had been removed the old base was thoroughly cleaned and the new concrete surface placed directly thereon with an average depth of four inches. It was found that the old base in some spots was very irregular and when a depth of three and one-half inches of new concrete could not be attained, we used mesh reinforcement. The concrete was mixed just as dry as it could be used.

The concrete section of the street was under the direct supervision of Truman A. Smith, assistant engineer, who gave this work his undivided attention. The paving of the asphaltic section was directed by Thomas P. Kroutter, city maintenance engineer, and Joseph Heiter, city foreman. The above were ably assisted by the efficient WPA foreman, and I attribute the good results obtained on this work to the men directly in charge.

The entire yardage of the project was 14,000 square yards.

The work could not have proceeded to such a satisfactory conclusion if we had not received the hearty cooperation of the WPA officials and they are to be commended for their interest in the work. It was a pleasure to work with them every step of the way.

This was a worthwhile WPA project. The improvement had needed attention for a considerable time, but due to financial stress the city was not in a position to proceed with it. This work was carried on with dispatch and the expense was in line with what the cost would have been had it been done by contract.

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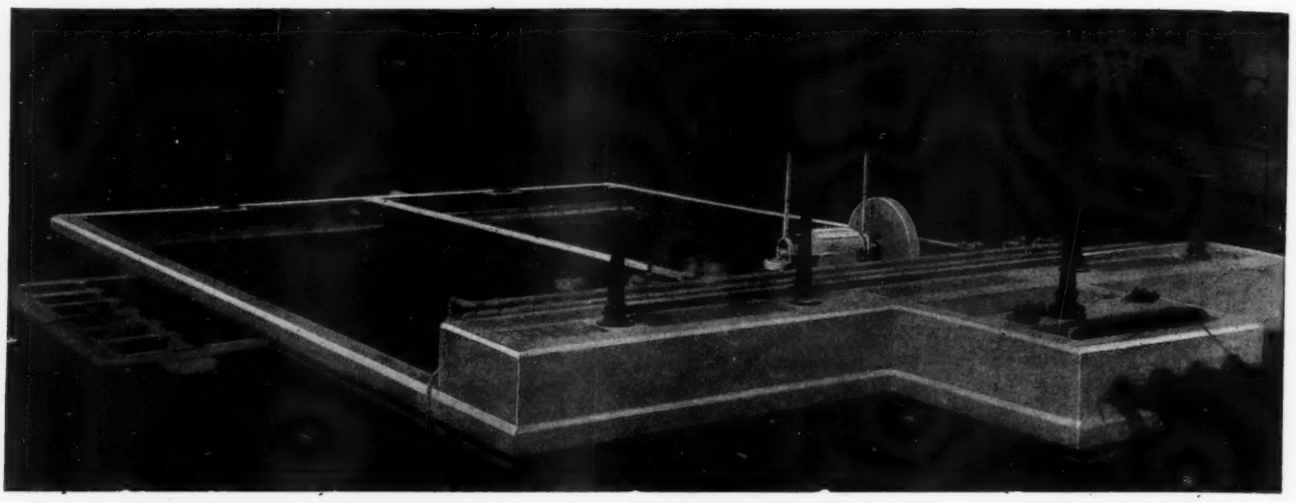

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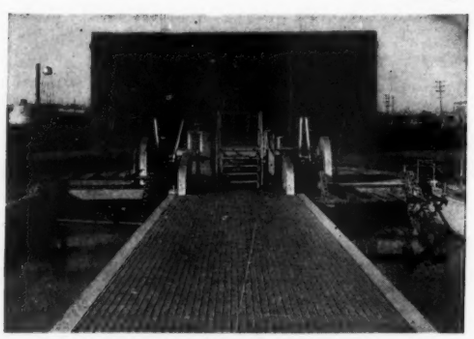

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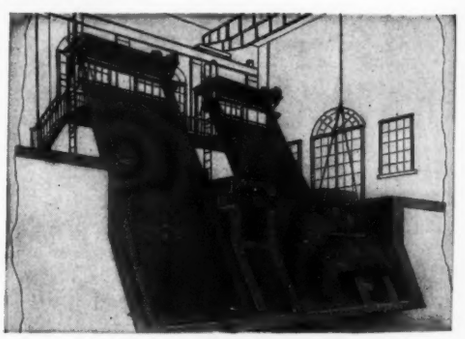

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When you need special information—consult the *classified* READERS' SERVICE DEPT., pages 63-65

Water Supplies In Indiana State Parks

By Denzil Doggett

Asst. State Engineer, Indiana Conservation Department

USUALLY our properties are located in waste lands on which the provision of an adequate public water supply from wells in the usual manner is a practical impossibility. In state parks, where the use of water is greater than in other properties, this problem has been solved in several different ways. At Turkey Run, a gravity sand filter plant was built, using raw water from Sugar Creek. At McCormick's Creek a gravel wall well was sunk in the White River bottoms, three quarters of a mile from the service area. Water for Indiana Dunes State Park is pumped from 40 slotted screen well points sunk in the beach sand below the level of Lake Michigan and connected by a header connected with the pump. At Pokagon, a flowing well is utilized for the hotel water supply, while that for the camping and picnic grounds and boys' camp comes from an ordinary well. At Lincoln State Park, a filter plant equipped with a pressure filter takes raw water from an artificial lake. At Shakamak, a six-inch pipe line supplies the park from Jasonville's water system. In Clark County State Forest, a pressure filter plant utilizes raw water from an impounding reservoir and provides potable water for picnic areas. In other state forests, wells of varying sizes are depending upon the amount of water needed for the area involved.

At Brown County State Park, an infiltration gallery provides potable drinking water. At the Brown County Game Preserve, water is furnished by cisterns provided with a sand filter, utilizing water from the building's roofs. At Jasper-Pulaski Game Preserve, a well point system of three slotted points furnishes water for all game farm operations, as well as for public use.

A former weak point in the department's water supply systems has been the lack of adequate storage facilities to take care of peak loads on week-ends. This has been remedied by the addition of storage reservoirs of capacities ranging from 20 to 40 thousand gallons.

Distribution mains have been installed from the source of supply to all areas which the public is to use. This insures potable water from a central source which can be checked periodically for purity. Having a single source of water for each land unit makes chlorination a simple matter and uses only one chlorinator, thereby cutting the cost of water per thousand gallon unit.

Two sprinkling systems have been installed. These are the pop-up type of sprinklers and use untreated water from a natural and an artificial lake. This water is pumped directly to the sprinklers by motor driven centrifugal pumps.

One phase of engineering and construction work which has been relatively important the last few years is that relating to the design and construction of earth dams with some type of concrete spillway. Twelve of these dams have been built and two are still under construction. Three more have been planned and are being started. The dams which have been built and which are being planned will impound 500 acres of water. Our largest one is now under construction at the Jackson County State Forest. It will contain 95,000 cubic yards of earth fill and 1180 cubic yards of concrete spillway, and will form a 165-acre lake, with a 20-acre fish hatchery below it.

This material is extracted from a paper by Mr. Dogget, presented at the 22nd annual Purdue Road School.

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There has been included in the section on sewerage some quite recent data relative to rainfall, anticipated population of cities, sewer design and related subjects.

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Traveling Water Works Laboratory

The most recent development in the field of water purification is a traveling water works laboratory developed by F. E. Stuart, of the Activated Alum Corp. of New York.

This unit will consist of a 19 foot Curtiss Aero-Car and will contain the latest type equipment available for the economical and efficient operation of a water plant and also some especially designed for research work. It will also carry samples of coagulants, including regular alum, activated alum, sodium aluminate, ferrous sulphate, ferric sulphate, ferric chloride, and coagulants developed or used in Europe.

Aside from coagulants, the unit will contain all types of activated carbons, both powdered and granular, and odor control apparatus to determine the efficiency of each. Activated carbons will include, Nuchar, Norit, Cliffchar, Darco, Klearit, Magnechar, Minchar, and others developed abroad.

Some of the interesting features of design include a stirring machine, designed by Bingham of Richmond, and built by Phipps & Bird (furnished through the courtesy of Phipps & Bird). This stirring machine is silent in operation, has a most unusual range of control varying from 2 R.P.M. to 110 R.P.M. The speed of the stirring blades is under control at all times because a tachometer reads direct in R.P.Ms. of the stirring arms. Rapid determination of floc characteristics can be made because of the design in placing and removing stirring arms without breaking of the floc already formed.

Other apparatus necessary for determining the effectiveness of different type coagulants compared to activated alum is a newly designed Air-Mixer—utilizing a small electric blower and porous diffusion plates, such as those used in activated sludge plants. This Air-Mixer is to be used in comparing mechanical mixing with air mixing in the treatment of trade wastes and domestic sewage.

Included in the routine laboratory apparatus are a few pieces of equipment especially valuable in field work, such as the latest type Hellige Aqua Tester, and Hellige Turbidimeter (furnished especially for this unit through the courtesy of Wallace & Tiernan Co., Newark, N. J.). With this apparatus the slightest traces of turbidity and color can be detected.

The apparatus to determine how much "free alum" is left after treatment is the Baldwin Residual Alumina Set, which is also included in this unit (furnished through the courtesy of the developer of the process, Baldwin, of the Richmond, Va., Water Department).

Aside from the equipment commercially available and that especially designed for this unit to determine coagulation efficiency, is a most complete taste and odor control section. This is designed to determine the effectiveness of coagulation on taste removal and the efficiency of different type activated carbons. All of the odor detection equipment is Pyrex. Provision has been made to have odor free water available for these determinations. So sensitive is the apparatus and method of detection that odor dilutions of 1 to 100 are many times readily detectible.

Some of the interior features incorporated in the design of the mobile laboratory may be interesting. Water pressure of 70 pounds is available; equipment includes porcelain sink; lavatory; complete galley; refrigerator; retractable Pullman type berths (two); 6 and 110 volts lighting system; built-in radio; stenographic type typewriter desk; built-in library, containing all the latest books and manufacturers' pamph.ets on water and sewage treatment.

The mechanical features include, Bendix Aviation type power brakes on the Aero-Car; safety glass throughout; aeroplane type coupler to the power car; communication system between power unit and Aero-Car; roller type window screens; aluminum foil heat insulation between ceiling and roof; sound proofing felt between outer body and inner body, to prevent road shocks, jars, and noise.

Mr. Stuart states that the story behind this traveling laboratory would be incomplete without acknowledging the helpful assistance in the design and construction to those who extended their cooperation and aid, including; Smith, Bingham, and Baldwin of the Division of Water Supply, Richmond, Va.; R. W. Fitzgerald, Chief Chemist, Division of Water Supply, Norfolk, Va.; Ed. S. Hopkins, Chief Chemist, Division of Water Supply, Baltimore, Md.; E. L. Filby, Chief Engineer; Black and Veatch, Consulting Engineers, Kansas City, Mo.; Phipps & Bird, Richmond, Va.; Wallace & Tiernan, Newark, N. J.; Curtiss Aero-Car Co., Miami, Fla., and W. A. Taylor Co., Baltimore, Md.

Saving Money on Traffic Line Marking

Some data have been collected by Littleford Bros. showing the savings obtained by the use of traffic marking equipment, as follows:

Maryland State Highway Dept.—Formerly used a machine of brush type using ten men to a gang. Traf-O-Spray requires only five men. Result: Labor cut in half, paint consumption reduced 30%.

Kentucky State Highway Dept.—They use but five gallons of paint per mile on a 4" line. Four men put down 5 miles per day. Operator marked pavement faster than men can move flags or blocks to keep off traffic. Two additional men would speed it up about 100% if desired.

City of Cincinnati—Boulevard marking. Compared to hand brush methods, they put down a neater, longer wearing line with 6 men in 2 days than they used to get in 10 days with 10 men.

Milling Machine Company—Marking factory floors, Formerly used bucket and hand brush. Reduced their labor cost 75%, saved 10% in paint, put down a smoother, more even line that lasts longer.

Catalogs and Booklets

Meniscus and Thermometer Readers:

The meniscus reader is equipped with a clamp and a telescope so that exact readings can be made on tubes from 6 mm to 21 mm in diameter. The thermometer reader is of somewhat the same general construction, and permits the reading of thermometer scales graduated in small intervals. Both of these nifty products are made by A. H. Thomas Co., Philadelphia, Pa. Folder on request.

Moto-Mixer and Agitators:

If the Chain Belt Co., of Milwaukee, Wisc., turn out as good mixers as they do catalogs, you will be especially interested in their products. In this booklet, which contains nearly all the colors of the rainbow, are discussions on profits, applications, users, your questions, Rex answers, sizes, agitators, the men and the plant. Dog-gone nice catalog, with one of these fancy spiral bindings. Sent on request, no charge.

Laboratory Glassware:

Kimble Glass Co., Vineland, N. J., has a 64-page catalog of "blue-line" graduated glassware, which ought to be most interesting reading to everyone engaged in laboratory work. Mighty fine catalog; covers equipment from *Acidmeters* to *Water Test, Graduated Cylinders*. Sent on request to the above address.

Pebbles on Parade:

This is the title of a story about the Grand Coulee dam. The Jeffrey Mfg. Co., Columbus, O., which furnished much of the equipment, has written an interesting account of the dam and of the equipment used for handling the gravel. Very well illustrated. You'll enjoy it. Sent on request to Jeffrey.

Underpass Drainage:

A 4-page bulletin on centrifugal pumps for underpass drainage has been issued by Worthington Pump & Machinery Corp., Harrison, N. J.

The American Water Works Association meets in Los Angeles, Calif., June 8 to 12, with headquarters at the Hotel Biltmore. The usual interesting technical and social program has been provided. The July issue of Public Works will carry a summary of the meeting.

Book Reviews

Sewerage:

By A. Prescott Folwell. Eleventh Edition; 400 pages; 123 illustrations. John Wiley & Sons, Inc., N. Y. $4.50.

The mere fact that this book has gone through eleven editions and that more than 31,000 copies have been sold is pretty fair proof that it has been found really valuable. Perhaps more than any other factor in creating this demand has been the ability of the author to present with clarity and thoroughness the details of design and construction. Have you a problem in sewerage? The chances are that in this book you will find a helpful answer.

In its 400 pages, the author covers very thoroughly such subjects as the amounts of storm and sanitary sewage, the flow in sewers, designing, detail plans, construction, supervision of construction, planning sewage treatment and the methods of sewage treatment.

About 160 pages are devoted to sewage treatment, beginning with principles and definitions, and covering the composition of sewage, the chemistry and biology of sewage, disposal by dilution, removing suspended matter, secondary treatment, sludge digestion and gas utilization, sludge treatment, chemical and mechanical aids, etc.

Engineers, many of whom studied earlier editions of this text while in college, will find it of particular value for reference use.

The Municipal Year Book, 1936

Clarence E. Ridley and Orin F. Nolting, editors. International City Managers' Association, Chicago. 475 pp. 1936. $4. Cloth-bound.

The third issue. In the first 125 pages 23 leading authorities discuss by analysis and interpretation the specific events and developments in 1935 in as many fields of municipal administration. Part II of the yearbook is devoted to a discussion of local governmental units in the United States. In the first article there is a list of the number of local government units by types and states, with a detailed analysis of changes which have occurred in the last four years. Next is an analysis of pertinent facts with regard to the metropolitan districts of over one million population. Also for each of the 960 cities of over 10,000 such information as population, area, form of government, number and terms of councilmen, and utilities owned and operated.

Municipal personnel is the subject of Part III of the yearbook, over 100 pages being included in this section.

Part IV is devoted to municipal finance. An analysis of trends in municipal debt, by Carl H. Chatters and Elton D. Woolpert, indicates the growth of debt, purposes for which debt is incurred, bond sales, interest rates, and other information from 1916 to January 1, 1936.

A new feature in Part V, "Sources of Information," is a list of model municipal ordinances. This section also outlines the services and information available from 150 federal agencies and from many national organizations, selected books, pamphlets, and reports published in 1935, and a select list of periodicals of value to municipal officials.

Collisions in Street and Highway Transportation:

By Barry Mulligan. 310 pp.; 52 ill.; Dorrance & Co., Inc., Philadelphia. $3.

The title of this book gives no adequate idea as to the interest and value, and the broad scope of the contents. Perhaps a few chapter headings will tell a better story: Four main aspects of the traffic problem; the engineer's problem of street and highway safety; city planning and traffic safety; parking (including parking garages, parking squares and underground parking); commercial vehicles; taxicabs; the municipality's problem in costs; traffic coordination; studying the causes of accidents; factors in collisions; intersections; proposed new type of intersection; compulsory control devices; selling safety; a program.

A study of this book may not enable you to solve traffic problems in your city, but it will certainly give you plenty of new ideas and, quite likely, a new viewpoint that may be of unexpected interest and value.

Water Supply for Summer Camps:

In our May issue, considerable space was devoted to descriptions of apparatus suitable for treating camp water supplies by hypochlorite solutions. Among the apparatus described was the Phipps and Bird solution feeder. At the end of the paragraph describing this feeder was a reference to the "Stirred Feeder" with the statement that this particular piece of apparatus was not well adapted to camp water supplies.

This did not refer to the Phipps & Bird solution feeder, which is especially well adapted to camp water supply work, and has been used quite widely in this field and in CCC camps. This solution feeder is exceptionally reliable and capable of long service. One of the first of these units was put in service several years ago feeding ferric chloride solution in a New York state sewage treatment plant, and is still operating very satisfactorily.

The reason for not recommending the "Stirred Feeder" for this work was the fact that it uses milk of lime or chloride of lime, and is especially adapted to handling them. But for camp water supplies, Perchloron or HTH are recommended instead of chloride of lime.

Manufacturers News

The Cooper-Bessemer Corporation has been awarded a contract by the Panhandle Easter Pipeline Company, of Kansas City, Mo., for 14 twin-tandem gas-engine-driven compressor units. Largest order since 1930 for equipment of this kind, it calls for twelve 1300-H.P. units, and two 1000-H.P. units. The engines will pump natural gas from the Texas Panhandle to the city of Detroit, through one of the longest natural-gas pipe lines in the world, extending a distance of 1350 miles between western Texas and a point north of Indianapolis.

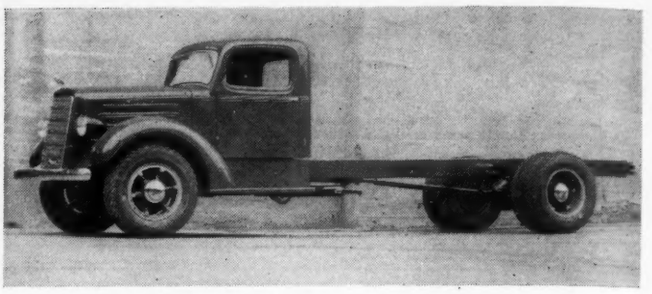
White Motor Co., Cleveland, O., reports order for 685 motor trucks from the War and Agriculture Departments of the Federal Government.

The M. & H. Valve and Fittings Company of Anniston, Ala., have just completed shipping 200 fire hydrants to the City of Milwaukee. These hydrants are of the special "Milwaukee" type, having but one outlet. The 2½-inch hose outlet is part of the cap which closes the steamer outlet. This company has also begun work on a contract for several hundred water valves for the City of Cincinnati, in the smaller sizes. Their plant is now running at full capacity, with the major portion of orders being received coming from normal municipal and industrial sources, rather than from purely government-financed projects, they report. Whitfield Clark is president; Charles S. Martin, vice-president and general manager; C. N. Evans, treasurer, and Jos. W. Spradley, secretary and sales manager.

The 24-inch and smaller valves for the Birmingham Industrial Water Supply project have been awarded to the M & H Valve & Fittings Co., Anniston, Ala., and the 36-inch and larger valves to the Ludlow Valve Co., Troy, N. Y.

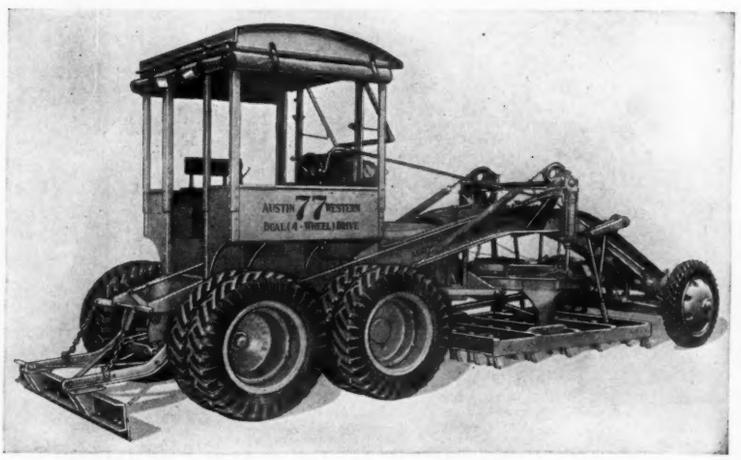
The M. & H. Valve & Fittings Co. plant at Anniston, Ala.

NEW EQUIPMENT



New Mack Model EH truck which rates at 18,000 pounds gross. Weight 30% front, 70% rear, 6-cylinder, 79 h.p. motor.

The Coleman pH electrometer is manufactured by the Wilkens-Anderson Co., Chicago, Ill. Direct pH readings are quickly made; turbid, colored, greasy, or gaseous materials have no effect; nor do oxidizing or reducing solutions. Catalog on request.



This is a new black-top "scarifyer" just announced by Austin-Western. It consists of a 31-tooth unit mounted in place of the blade and standard scarifying equipment. All operations are easily controlled.

This is one of the new 700 series of Harnischfeger shovels, a 1½-yard diesel. Fully convertible. Has lots of power and speed and its builders claim a lower cost per yard of dirt moved.

Austin-Western Road Machinery Co. has issued a 24-page booklet featuring their Badger Shovel. This booklet contains lots of dope on how to move dirt on all sorts of jobs. Sent on request.

Roll Crushers:

A brief (8-page), but complete, bulletin on the roll crusher has been issued by the Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn. Tells a lot about this type of crusher; if you want to find out how it fits your local needs and conditions, write for a copy. Sent on request.

Jaeger Mixers:

36 pages; complete; properly illustrated, with all sorts of action, cut away, phantom and still views. Fully up to the usual high standards of Jaeger catalogs. Write Jaeger Machine Co., Columbus, O., for a copy ofM-36.

Jaeger Pumps:

The third in the trilogy of new and very attractive Jaeger catalogs. 36 pp.; properly illustrated, capacity, performance curves, installation data and information on hydraulics. Write Jaeger Machine Co., Columbus, O., for free copy of P-36.

Modern Municipal Sanitation:

A booklet by the Dorr Co., 8 pages, presents in brief form a description of the Dorr products, including coarse screens, grit removal apparatus, and equipment for sedimentation, sludge digestion, aeration, mixing and trickling filters. Sent on request. Dorr Co., 247 Park Ave., N. Y.

Caterpillar Auto Patrol:

The booklet obtains the maximum value from half-tone illustrations, the principal model views of the four Auto Patrol models, extending across two full pages. Almost every leaf of the 38-page catalog contains large reproductions of parts and assemblies. Action photographs depict the year-around use of the machines in road construction, finishing and maintenance, oil mix, scarifying and snow removal. Copies may be obtained from the manufacturer or any "Caterpillar" Distributor.

"K" Tractors:

These tractor folks get out some beautiful booklets and this one is well above the average in appearance. Describes and illustrates the Allis-Chalmers Model K, standard and wide tread tractors. Sent on request, Allis-Chambers Mfg. Co., Milwaukee, Wisc.

Carryall Scrapers:

LeTourneau, Peoria, Ill., announces carryall scrapers in 12, 8 and 6-yard sizes for tractors 95 to 40 h.p. Catalog on request.

Centrifugal Pumps:

Worthington Pump & Machinery Corp., Harrison, N. J., has issued a 4-page folder on multi-stage volute centrifugal pumps.

Readers' Service Department

These booklets are FREE to readers of PUBLIC WORKS.

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bulletin just issued by Filtration Equipment Co., 350 Madison Ave., New York, N. Y.

Couplings for Pipe

386. This sixteen-page booklet is a reprint of a magazine article by a consulting engineer. It describes in detail the installation of a 42" water line; contains specific information regarding pipe joints, field organization, laying pipe, tests, back-filling, etc. Sent free by S. R. Dresser Manufacturing Company, Bradford, Pa.

Fire Hydrants

388. Two new bulletins on M-H fire hydrants and fully bronze mounted gate valves are now ready. Contain full specifications and instructions for ordering, installing, repairing, lengthening and using. Write M. & H. Valve & Fitting Co., Anniston, Ala.

Gate Valves

390. 28 page catalog contains illustrations and complete specifications of M-H standard and extra heavy iron body gate valves, horizontal swing check valves, flanged fittings and flanges, etc. Sent promptly on request by M. & H. Valve & Fittings Co., Anniston, Ala.

Glass Covers

393. Full details regarding the use of Lord & Burnham Glass-Overs at Middletown, N. Y.; Marion, Ohio; Cleveland, Ohio; Freeport, N. Y.; Kitchener, Canada; West Chester, Pa., and other places are given in bulletins 22 to 33. Sent promptly on request to Lord & Burnham Co., Irvington, N. Y.

Laboratory Equipment

400. The Phipps & Bird Stirrer, the solution feeder, a forthcoming stirrer using air for mixing, and all sorts of laboratory equipment for water and sewage plants. Bulletins and folders covering these pieces of equipment are complete and interesting. Phipps & Bird, Inc., 915 East Cary St., Richmond, Va.

Manhole Covers and Inlets

403. Nuisance from loose, noisy manhole covers is eliminated by the use of Westeel rubber cushioned manhole covers and gratings. Six special advantages are explained in a new illustrated bulletin just issued by the West Steel Casting Co., 805 East 70th St., Cleveland, Ohio.

404. Street, sewer and water castings made of wear-resisting chilled iron in various styles, sizes and weights. Manhole covers, water meter covers, adjustable curb inlets, gutter, crossing plates, valve and lamphole covers, ventilators, etc. Described in catalog issued by South Bend Foundry Co., South Bend, Ind.

405. "Standard Construction Castings" contains 32 pages of useful data sheets giving specifications and detailed sketches of a wide variety of frames, manhole covers and other castings. Every municipal engineer should have one. Flockhart Foundry Co., 82 Polk St., Newark, N. J.

Pipe, 2-inch Cast Iron

407. The new McWane 2" cast iron pipe in 18-foot lengths has innumerable uses in water and sewage work. Send for the new McWane bulletin describing this pipe, the various joints used, and other details about it. McWane Cast Iron Pipe Co., Birmingham, Ala.

Pipe Forms

409. Making concrete pipe on the job to give employment at home is the subject of a new booklet just issued by Quinn Wire and Iron Works, 1621 Twelfth St., Boone, Ia., manufacturers of "Heavy Duty" Pipe Forms. Sent promptly on request.

Pipe Joints

410. New folder describes in detail a new type of pipe joint—the Dresser Compression Coupling, Style 65, which is compact and self contained, makes a permanently tight joint under all conditions and is installed on plain end pipe in a few seconds with only one tool, a wrench. Get your copy today. S. R. Dresser Mfg. Co., Bradford, Pa.

Pipe Joint Compound

411. A new bulletin has recently been issued giving full details concerning Tegul Mineralead, a quick-sealing, trouble-free compound for bell and spigot joints which permits immediate closing of the trenches. Write The Atlas Mineral Products Co. of Pa., Mertztown, Pa.

Taste and Odor Control

412. How, when and where activated carbon can and should be used to remove all kinds of tastes and odors from water supplies is told in a new booklet just issued by Industrial Chemical Sales Co., Inc., 230 Park Ave., New York, N. Y. 32 pages, table, illustrations and usable data.

Pumps and Well Water Systems

413. Installation views and sectional scenes on Layne Vertical Centrifugal and Vertical Turbine Pumps, fully illustrated and including useful engineering data section. Layne Shutter Screens for Gravel Wall Wells. Write for these three descriptive booklets. Layne & Bowler, Inc., Dept. W, General Office Memphis, Tenn.

Protective Pipe Coating

415. Coal-tar Pitch Enamels for exterior and interior linings for steel water lines; highly resistant to water absorption, soil acids and alkalis. Technical specifications for materials and their application will be sent on request. The Barrett Company, 40 Rector St., New York, N. Y.

Pumping Engines

417. "When Power Is Down," gives recommendations of models for standby services for all power requirements. Sterling Engine Company, Buffalo, N. Y.

Rubber Lined Pipes and Pumps

418. New, 68-page catalog describes Ace rubber lined pipe and fittings, hard or soft rubber lined centrifugal pumps and Ace hard rubber double acting pumps, for chemicals used in treating sewage and water and for acids and other corrosive liquids. Contains illustrations and specifications. Issued by American Hard Rubber Co., 11 Mercer St., New York, N. Y.

Runoff & Stream-Flow

420. Technical information on measuring run-off, both from small areas, for storm sewer design, and from large areas for determining water-shed yield, and instruments for measuring. Julien P. Friez & Sons, Baltimore, Md.

Screens, Sewage

421. The simple, automatic Loughlin, self-cleaning travelling screen is fully described in an interesting bulletin issued by Filtration Equipment Co., 10 East 40th St., New York, N. Y.

423. Sewage screens (Tark, Brunotte, and Straightline) for fine and coarse sewage; Straightline Collectors for Settling Tanks (Sludge, Scum and Grit), and Mechanical Aerators for activated sludge plants. Link-Belt Company, 307 No. Michigan Ave., Chicago, Ill. Book 642.

Small Septic Tanks

425. Very handy and complete data on small septic tanks and their installation, and also on the construction of means for final disposal of the tank effluent; also on waterless chemical toilets. San-Equip, Inc., 615 East Brighton Ave., Syracuse, N. Y.

Rainfall Measurement

429. The measurement of precipitation, exposure of gauges, description of apparatus for measuring rainfall, both rates and amounts. Bulletin RG and Instruction Booklet. Julien P. Friez & Sons, Baltimore, Md.

Screens

430. Water Screen Book No. 1252, describes water screens and gives complete technical information about them. Link-Belt Co., 307 No. Michigan Ave., Chicago, Ill.

Sludge Bed Glass Covers

432. Sludge Bed Glass Covers—"Super-Frame." Hitchings & Co., Elizabeth, N. J. Offer A. I. A. File 101SB, describing glass covers for sludge and sprinkler beds; details, specifications and cost data.

Sludge Incineration

438. A multiple hearth furnace which meets the most exacting municipal sanitary requirements for the incineration of sewage sludge—produces a fine ash or partially dry sludge for fertilizer—is described and illustrated with drawings and photographs in bulletins issued by Nichols Engineering and Research Corp., 40 Wall St., New York, N. Y. Operation as well as installation data is given.

440. Disposal of Municipal Refuse: Planning a disposal system; specifications. The production of refuse, weights, volume, characteristics. Fuel requirements for incineration. Suggestions for plant inspection, 45 pp., ill. Also detailed outline of factors involved in preparation of plans and specifications. Morse-Boulger Destructor Co., 202P East 44th St., N. Y.

Sludge Removal Equipment

442. If you are interested in economical sludge removal, write for the latest bulletin describing and illustrating Louden Monorail equipment which is adapted to open or closed beds. Full details sent promptly by the Louden Machinery Co., 400 West Ave., Fairfield, Iowa.

Swimming Pool Equipment

444. Filters, chlorination, underwater lights and other supplies for swimming pools are very thoroughly described in literature and folders. Plans and layouts. Everson Filter Co., 625 W. Lake St., Chicago, Ill.

445. Data and complete information on swimming pool filters and recirculation plants; also on water filters and filtration equipment. For data, prices, plans, etc., write Roberts Filter Mfg. Co., 640 Columbia Ave., Darby, Pa.

Treatment

448. New 31-page catalog covers complete conveying, screening and reduction machinery for water purification and sewage treatment; describes and illustrates the design features of Jeffrey self-cleaning bar screen, combined screen and grinder, sewage screenings grinder, grit washer, conveyor type and positive discharge sludge collectors and green garbage grinder—includes installation views. Catalog 615, Jeffrey Manufacturing Co., Columbus, Ohio.

449. Installation views and considerable engineering data including capacity tables for settling tanks and layouts of typical arrangements for both final and primary tanks, are contained in a new booklet—No. 1542—just published for engineers by Link-Belt Company, 307 No. Michigan Ave., Chicago, Ill.

450. Standard Sewage Siphons for small disposal plants and PFT Rotary Distributors are new catalogs recently issued by Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill. The latter catalog contains typical plans and many illustrations of actual installations.

452. Eliminate sludge bed troubles, forget about weather conditions, odor nuisance, hail insurance and the like. Full details as to how Oliver United Vacuum Filters overcome these problems will be sent to all interested by Oliver United Filters, Inc., 33 West 42nd St., New York, N. Y.

453. Collectors and concentrators for modern sewage treatment plants, recent installations, and full data on aerators, and screens. Link-Belt Co., 307 No. Michigan Ave., Chicago, Ill., and Philadelphia.

454. Full information regarding their newest equipment for sewage treatment and water purification will be sent on request by The Dorr Co., 247 Park Ave., New York, N. Y.

For the Engineer's Library

The editors will be glad to assist readers in getting copies of publications mentioned here.

Driveway Construction for Home Drive Makers

To help the homeowner build his private driveway or to contract for it, the Bureau of Public Roads, U. S. Department of Agriculture, has prepared a pamphlet, "Construction of Private Driveways."

Drives of stone, gravel, bituminous material, concrete and brick are described. Drawings and photographic illustrations show several kinds, of "ribbon" surfaces and full-width surfaces with dimensions. The pamphlet includes tables for rapid estimating of quantities of materials. For example, a gravel or crushed stone drive, 6 inches thick and of the ribbon type, will require about 9.5 cubic yards of material per 100 feet of drive, assuming 10 percent shrinkage of material due to compaction. If crushed stone or gravel costs $1.50 per cubic yard, then material for the drive will cost $14.25. Similarly, full width surfacing will require 14.3 cubic yards and the material will cost $21.45.

One type of concrete drive, 5 inches thick of the ribbon type requires 6.2 cubic yards per 100 feet of drive and full width surfacing requires 10.3 cubic yards.

There is a wide range of types of drives from which the homeowner may select. The choice will be influenced by materials available and by their cost.

Copies of the pamphlet may be obtained from the Bureau of Public Roads, Washington, D. C.

Standard Diesel Engine Practice:

156 pp.; 29 ill.; published by Diesel Engine Manufacturers Ass'n., N. Y.

Some five years ago, this association published a text which was intended to help to a definite understanding of diesel practices and terms. This text aims to help users and consulting engineers to bring their diesel background up to date. For this reason, standard practices of to-day are outlined, notes on the selection of engines are amplified, details in regard to plant layouts are presented and coordinated with suggested forms for specifications, economics of diesel power are treated, and a standard field test code is presented.

Although the general characteristics of all types of diesel engines are the same, essentially, the subject matter of this text deals primarily with heavy duty, low and medium speed engines of sizes commonly used in stationary power plants—200 hp., and larger.

The book is printed and distributed by Diesel Publications, Inc., 192 Lexington Ave., N. Y. No price information is given. It is possible that a request on your letter head might get a copy free.

Spiral Pipe:

40-page booklet: gives full details on Taylor Spiral welded pipe, with dimensions, weights, etc. A few pages in the back give good data on flow of water in pipes, including a couple of extra good flow charts giving graphic solution of flow of water in pipes. Other hydraulic data, too. Sent on request to Taylor Forge & Pipe Works, Chicago, Ill.

Lubricating Highway Machinery:

A rather complete article on lubrication and maintenance of highway machinery, with special reference to gasoline and diesel engines, air powers and motor driven equipement, covering shovels, cranes, draglines, tractors, pavers and other equipment. Sent on request to Lubrication, 135 East 42nd St., N. Y.

Drainage Products:

A 46-page book, published by Armco Culvert Mfrs. Ass'n., Middletown, O., which outlines where drainage is needed; describes Armco pipe, fittings and connections; shows how to determine culvert sizes; and gives a great deal of other data in text and pictures. Sent on request.

Stabilization Specifications:

Revisions according to the latest findings in service behavior of stabilized roads have been incorporated in a new edition of "Typical Specifications for Low-Cost Wearing Surfaces for Roads Stabilized with Calcium Chloride and Binder Soil" which will be sent on request. Don't let the long title scare you. Write for Bulletin 20. Calcium Chloride Ass'n., Penobscot Bldg., Detroit, Mich.

Cross-Connections:

This is a discussion of methods of contamination of water supplies through cross-connections in the plumbing system, together with recommended methods of correcting and eliminating such conditions. Produced by the State Board of Health and the Bureau of Plumbing of Wisconsin; script by A. A. Kalinske, Prof. F. M. Dawson and Frank R. King. 76 pages. Sent on request, while the supply lasts. State Board of Health, Madison, Wisc.

"Hot Oil":

"Hot Oil, the Problem of Petroleum" is a non-technical, apparently unbiased, and certainly interesting 308-page study of the American petroleum industry, of the possibilities of preserving the nation's petroleum supply, and of the question of federal control. It has been written by Samuel B. Pettengill; published by Economic Forum C., New York, N. Y. ($2).

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